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IMPA Rio de Janeiro (Visiting Researcher)
Brazil

David P. Williamson
Cornell University
USA

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Université Catholique de Louvain
Belgium

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ISMP2015 PITTSBURGH
22nd INTERNATIONAL SYMPOSIUM on MATHEMATICAL PROGRAMMING
JULY 12-17

Carnegie Mellon University

Tepper School of Business
Carnegie Mellon University
5000 Forbes Ave
Pittsburgh, PA 15213-3890

It is a pleasure to welcome you to the 22nd International Symposium on Mathematical Programming (ISMP 2015), the most important meeting of the Mathematical Optimization Society (MOS). Over the past 10 years, the triennial ISMP meetings have grown significantly, and the 2015 edition will feature roughly 1,500 technical presentations covering all aspects of mathematical optimization.

The expertise of the INFORMS staff in managing the administration of the conference has been a tremendous help, as well as the use of INFORMS' web registration and abstract processing infrastructure. The local organization has been a joint venture of the University of Pittsburgh and Carnegie Mellon University. Despite having campuses located side by side and having together more than 35,000 students, it proved impossible to organize ISMP on campus(es). We hope that the conference hotel in downtown Pittsburgh will prove convenient and comfortable. Don't forget that the universities are a short bus ride from the conference and visiting them could give you a different feel for Pittsburgh than your downtown experience.

Pittsburgh is a pleasant city to live in, but discovering its most attractive sides requires some effort. Its many ethnic neighborhoods, each with a specific atmosphere, are worth a look. You might be aware that Pittsburgh has been a movie set for several blockbuster films ("Batman: The Dark Knight Rises" is the most recent one), and the number and diversity of cultural events offering is remarkable for a city its size. The faint of heart might want to avoid some local delicacies (e.g., a sandwich of fried bologna, egg, french fries, and cole slaw), but good Italian, Polish, and Hungarian dishes can be found (even if you are Italian, Polish, or Hungarian).

We hope that you will find the Symposium both enjoyable and valuable.

François Margot
Tepper School of Business
Carnegie Mellon University

SUNDAY, JULY 12

3:00pm-6:00pm	Registration	Grand Ballroom Foyer
6:00pm-7:30pm	Opening Ceremony	Grand Ballroom
7:30pm-9:00pm	Welcome Reception	Kings Garden Ballroom

MONDAY, JULY 13

8:00am-5:30pm	Registration	Grand Ballroom Foyer
9:00am-5:30pm	Exhibits	Grand Ballroom Foyer
9:00am-9:50am	Plenary: Jim Geelen	Grand Ballroom 1 & 2
9:50am-10:20am	Coffee Break	Grand Ballroom Foyer
10:20am-11:50am	Technical Sessions (MB)	Lobby & Ballroom Levels
11:50am-1:10pm	Lunch Break (on your own)	
1:10pm-2:40pm	Technical Sessions (MC)	Lobby & Ballroom Levels
2:45pm-4:15pm	Technical Sessions (MD)	Lobby & Ballroom Levels
4:15pm-4:35pm	Coffee Break	Grand Ballroom Foyer
4:35pm-5:25pm	Semi-Plenary: Roberto Cominetti	Grand Ballroom 1
4:35pm-5:25pm	Semi-Plenary: Pascal van Hentenryck	Grand Ballroom 2
5:30pm-7:00pm	Technical Sessions(MF)	Lobby & Ballroom Levels

TUESDAY, JULY 14

8:00am-5:30pm	Registration	Grand Ballroom Foyer
9:00am-5:30pm	Exhibits	Grand Ballroom Foyer
9:00am-9:50am	Plenary: Laurent El Ghaoui	Grand Ballroom 1 & 2
9:50am-10:20am	Coffee Break	Grand Ballroom Foyer
10:20am-11:50am	Technical Sessions (TB)	Lobby & Ballroom Levels
11:50am-1:10pm	Lunch Break (on your own)	
1:10pm-2:40pm	Technical Sessions (TC)	Lobby & Ballroom Levels
2:45pm-4:15pm	Technical Sessions (TD)	Lobby & Ballroom Levels
4:15pm-4:35pm	Coffee Break	Grand Ballroom Foyer
4:35pm-5:25pm	Semi-Plenary: Samuel Burer	Grand Ballroom 1
4:35pm-5:25pm	Semi-Plenary: Asu Özdaglar	Grand Ballroom 2
5:30pm-6:30pm	MOS Business Meeting (open to all)	Kings Garden 5
6:45pm-8:00pm	Optimization Discussion Group *Sponsor: INFORMS Optimization Society* (open to all)	Kings Garden 4

NOTE:
All events are held in the Wyndham Grand Pittsburgh unless otherwise indicated. For technical session rooms, see the Track Schedule on pages xvii-xxi.

BADGES REQUIRED FOR TECHNICAL SESSIONS
ISMP 2015 badges must be worn to all sessions and events. Attendees without badges will be directed to the registration desk to register and pick up their badges. All attendees, including speakers, cluster chairs and session chairs, must register and pay the registration fee.

COFFEE BREAKS
All coffee breaks will be held in the Grand Ballroom Foyer of the Wyndham Hotel.

DAILY EVENTS AND SESSIONS

WEDNESDAY, JULY 15

8:00am-5:30pm	Registration	Grand Ballroom Foyer
9:00am-4:45pm	Exhibits	Grand Ballroom Foyer
9:00am-9:50am	Plenary: Stephen Wright	Grand Ballroom 1 & 2
9:50am-10:20am	Coffee Break	Grand Ballroom Foyer
10:20am-11:50am	Technical Sessions (WB)	Lobby & Ballroom Levels
11:50am-1:10pm	Lunch Break (on your own)	
1:10pm-2:40pm	Technical Sessions (WC)	Lobby & Ballroom Levels
2:45pm-4:15pm	Technical Sessions (WD)	Lobby & Ballroom Levels
4:15pm-4:35pm	Coffee Break	Grand Ballroom Foyer
4:35pm-5:25pm	Semi-Plenary: Michele Conforti	Grand Ballroom 1
4:35pm-5:25pm	Semi-Plenary: Tamara G. Kolda	Grand Ballroom 2
5:30pm-6:20pm	Tseng Memorial Lecture	Grand Ballroom 1
6:50pm-10:00pm	Conference Cruise & Banquet *Meet in the lobby at 6:50pm for walk to boat*	Wyndham Lobby

THURSDAY, JULY 16

8:00am-5:30pm	Registration	Grand Ballroom Foyer
9:00am-9:50am	Plenary: Daniel Kuhn	Grand Ballroom 1 & 2
9:50am-10:20am	Coffee Break	Grand Ballroom Foyer
10:20am-11:50am	Technical Sessions (ThB)	Lobby & Ballroom Levels
11:50am-1:10pm	Lunch Break (on your own)	
1:10pm-2:40pm	Technical Sessions (ThC)	Lobby & Ballroom Levels
2:45pm-4:15pm	Technical Sessions (ThD)	Lobby & Ballroom Levels
4:15pm-4:35pm	Coffee Break	Grand Ballroom Foyer
4:35pm-5:25pm	Semi-Plenary: Andrea Lodi	Grand Ballroom 1
4:35pm-5:25pm	Semi-Plenary: Werner Römisch	Grand Ballroom 2
5:30pm-7:00pm	Technical Sessions (ThF)	Lobby & Ballroom Levels

FRIDAY, JULY 17

8:00am-4:30pm	Registration	Grand Ballroom Foyer
9:00am-9:50am	Plenary: Daniel Spielman	Grand Ballroom 1 & 2
9:50am-10:20am	Coffee Break	Grand Ballroom Foyer
10:20am-11:50am	Technical Sessions (FB)	Lobby & Ballroom Levels
11:50am-1:10pm	Lunch Break (on your own)	
1:10pm-2:40pm	Technical Sessions (FC)	Lobby & Ballroom Levels
2:45pm-4:15pm	Technical Sessions (FD)	Lobby & Ballroom Levels
4:15pm-4:35pm	Coffee Break	Grand Ballroom Foyer
4:35pm-5:25pm	Semi-Plenary: Frank Vallentin	Grand Ballroom 1
4:35pm-5:25pm	Semi-Plenary: Ya-xiang Yuan	Grand Ballroom 2

Approximation and Online Algorithms
Clifford Stein
Columbia University
USA

David B. Shmoys
Cornell University
USA

Combinatorial Optimization
Volker Kaibel
Otto-von-Guericke-Universität Magdeburg
Germany

Andreas S. Schulz
Mass.Institute of Technology
USA

Complementarity and Variational Inequalities
Michael C. Ferris
Univ.of Wisconsin-Madison
USA

Jong-Shi Pang
Univ. of Southern California
USA

Conic Programming
Fatma Kilinç-Karzan
Carnegie Mellon University
USA

Levent Tunçel
University of Waterloo
Canada

Constraint Programming
Louis-Martin Rousseau
École Polytechnique de Montréal
Canada

Willem-Jan van Hoeve
Carnegie Mellon University
USA

Derivative-Free and Simulation-Based Optimization
Katya Scheinberg
Lehigh University
USA

Luis Nunes Vicente
Unversidade de Coimbra
Portugal

Finance and Economics
Pavlo Krokhmal
University of Iowa
USA

Karl Schmedders
Universität Zürich
Switzerland

Game Theory
Shuchi Chawla
Univ. of Wisconsin-Madison
USA

Nicole Immorlica
Microsoft Research New England
USA

Global Optimization
Jean-Philippe P. Richard
University of Florida
USA

Mohit Tawarmalani
Purdue University
USA

Implementations and Software
Ted Ralphs
Lehigh University
USA

Andreas Wächter
Northwestern University
USA

Integer and Mixed-Integer Programming
Andrea Lodi
Università di Bologna
Italy

Robert Weismantel
ETH Zürich
Switzerland

Life Sciences and Healthcare
Edwin Romeijn
Georgia Institute of Technology
USA

Andrew Schaefer
University of Pittsburgh
USA

Logistics Traffic and Transportation
Patrice Marcotte
Université de Montréal
Canada

Huseyin Topaloglu
Cornell University
USA

Mixed-Integer Nonlinear Programming
Sven Leyffer
Argonne National Laboratory
USA

Jeffrey T. Linderoth
Univ. of Wisconsin-Madison
USA

Multi-Objective Optimization
Matthias Ehrgott
Lancaster University
United Kingdom

Kaisa Miettinen
Univeristy of Jyväskylä
Finland

Nonlinear Programming
Frank E. Curtis
Lehigh University
USA

Philip E. Gill
Univ. of California-San Diego
USA

Nonsmooth Optimization
Amir Beck
Technion-Israel Institute of Technology
Israel

Marc Teboulle
Tel-Aviv University
Israel

Optimization in Energy Systems
Eddie Anderson
University of Sydney
Australia

Daniel Bienstock
Columbia University
USA

PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods
Matthias Heinkenschloss
Rice University
USA

Michael Hintermüller
Humboldt-Universität Berlin
Germany

Robust Optimization
Dimitris Bertsimas
Mass. Institute of Technology
USA

Dick den Hertog
Tilburg University
The Netherlands

Sparse Optimization and Applications
Maryam Fazel
University of Washington
USA

Michael P. Friedlander
University of California-Davis
USA

Stochastic Optimization
Shabbir Ahmed
Georgia Institute of Technology
USA

Suvrajeet Sen
Univ. of Southern California
USA

Telecommunications and Networks
Sergiy Butenko
Texas A&M University
USA

Mauricio G.C. Resende
Amazon.com
USA

Variational Analysis
Regina Burachik
University of South Australia
Australia

Alejandro Jofré
Universidad de Chile
Chile

SPEAKER GUIDELINES

Audio-Visual Services

All session rooms will be equipped with a computer projector, but please note that you must provide your own laptop or pre-arrange to share with others in your sessions.

- Please bring a power adaptor. We recommend that you do not attempt to run your presentation off the laptop battery.
- If your laptop is not compatible with AC power, please bring an electrical adaptor so you can connect to U.S. electricity.
- If your laptop is an Apple product, you will need the appropriate adapter for the external video output.
- Arrive at your session at least 15 minutes before it begins. All presenters in a session should set up and test the connection to the projector before the session begins.
- We encourage speakers to put their presentations on a USB flash drive as a backup.

Presentation Guidelines

The room and location of your session are listed in the Technical Sessions section of this program and in the Track Schedule, as well as on the conference mobile app. Please arrive at your session at least 15 minutes early for AV set-up and to check in with the Session Chair. Time your presentation to fit within your designated time span, leaving time for audience questions.

Program Information

If you have general questions about the conference or questions about your own presentation, stop at the Program Information Desk at ISMP Registration. We ask Session Chairs to notify the Registration Desk about any last-minute changes or cancellations; these changes will be posted outside the meeting rooms when possible.

For Assistance during Your Sessions: Session Monitor Desks

Session Monitor Desks are located in several areas close to the technical session rooms, and are staffed by students from Pittsburgh universities. If you have a problem in your session room related to AV or any other requests, please go to the Session Monitor Desk in the area to ask for assistance.

Courtesy to Fellow Speakers

Attendees are asked to be respectful of their colleagues by turning off cell phones and mobile devices before the presentations begin. Please note that use of cameras and recording devices is prohibited during sessions unless you have received prior permission from the speakers.

Letters of Attendance

All presenting authors will receive personalized letters of attendance. Look in your badge envelope for your letter. If you have questions, please stop by the ISMP registration desk.

SESSION CHAIR GUIDELINES

The role of the Chair is to coordinate the smooth running of the session and introduce each speaker. The chair begins and ends each session on time. Each session lasts 90 minutes, with equal time given to each paper. Also, please remind the audience to turn off all mobile devices and not record presentations without the prior permission of the speakers.

THANK YOU

The Optimization Firm

Session Signage

Office of Naval Research — ONR — Science & Technology

AV Technology

sas

Coffee Break

REGISTRATION INFORMATION

Registration

Your registration fee admits you to the complete technical program. The Opening Ceremony & Reception and the morning and afternoon coffee breaks are also included. The Wednesday evening conference cruise and banquet requires a separate payment in advance. If you did not purchase a ticket in advance and wish to do so now, check at the ISMP Registration Desk – a limited number of tickets may be available on site.

Cruise & Banquet Tickets

The Wednesday evening cruise and banquet is open to attendees and guests who registered and paid in advance for tickets. The ticket(s) is included in your registration envelope. There may be a limited number of tickets available on site in Pittsburgh. Go to the ISMP Registration Desk to inquire. Tickets are $75 for students and $95 for all other attendees.

THANK YOU

IBM

Conference Badge

mosek

Notepad & Pen

NSF

Student Travel Assistance

AMPL

Coffee Break

GUROBI OPTIMIZATION

General Support

INTERNET ACCESS, MOBILE APP

Wireless Access
Free wireless access is available in the Grand Ballroom Foyer, where ISMP Registration and exhibits are located. If you are staying at the Wyndham, you will also have wireless access in the hotel lobby, using your guest access information.

Conference Mobile App
ISMP is pleased to offer a free mobile app for smart phone and tablet users. It's compatible with iPhones, iPads, iPod Touches and Android devices. You can use the app to access conference information on the go, including:

- Session and presentation list with abstracts
- Search capability by topic, paper title, track and author
- Ability to create a personalized schedule of talks to attend
- Floor plans and event listings

Download the ISMP app for iOS on the App Store or Android on Google Play.

THANK YOU

ExxonMobil

Mobile App

EXHIBITS

See page xv for a complete listing of exhibitors. Some exhibitors will be making software tutorial presentations (see Track 12 on Monday and Tuesday).

Exhibits are open:
Monday, 9:00am-5:30pm
Tuesday, 9:00am-5:30pm
Wednesday, 9:00am-4:45pm

WHERE TO GO FOR LUNCH

There are dozens of good restaurants close to the Wyndham, offering everything from fast food to fine dining. Stop by the Welcome Pittsburgh Desk (Grand Ballroom foyer) for a complete list and advice, or check with the concierge at your hotel.

Here are some options for a fairly quick meal during the conference lunch break, 11:50am-1:10pm.

Market Square
Some restaurants shown on map:

Coffee shops: Starbucks, Dunkin Donuts, Einstein Bagel

Chipolte

Diamond Market Bar & Grill (#12)

Fat Tommy's Pizzeria (#15)

Five Guys Burgers & Fries

Jimmy Johns Sandwiches (#20)

Moe's Southwest Grill (#24)

NOLA on the Square (#29)

Noodles & Company

Original Oyster House (#32)

Primanti Brothers (#37)

The Simple Greek

Fifth Avenue Place Arcade Shops
(#16)

PPG Place Food Court & Retail
(#36)
Food courts with a variety of quick, casual food offerings.

Wyndham Hotel
Three Rivers Restaurant (#51)

OPENING CEREMONY & WELCOME RECEPTION

Opening Ceremony
Sunday, July 12
6:00pm-7:30pm
Grand Ballroom

Welcome Reception
7:30pm-9:00pm
Kings Garden Ballroom

We welcome you to Pittsburgh and ISMP 2015! The Opening Ceremony will feature the presentation of awards by the Mathematical Optimization Society. In addition, MCG Jazz will present a review of Pittsburgh's impressive jazz contributions, in music, photos and video. Following the ceremony, we invite you to step across the hallway to Kings Garden Ballroom to enjoy the Welcome Reception.

Jazz: The Pittsburgh Connection
Some of the greatest of the jazz greats – from both the past and the present – have a Pittsburgh connection. Did you know that Art Blakey, Stanley Turrentine and Erroll Garner were all Pittsburgh natives? As is Ahmad Jamal. Billy Strayhorn, another Pittsburgh son, was a world-class, classically trained composer indispensable to Duke Ellington's success. Strayhorn's "Take the A Train," one of the great jazz classics, refers to the subway line Strayhorn took when traveling between New York and Pittsburgh. A lineup of contemporary jazz musicians, such as Roger Humphries and Joe Negri, also hail from Pittsburgh. We'll get an introduction to the city's jazz history and its present from MCG Jazz, an organization dedicated to preserving and promoting jazz through performance and teaching. Their musical review will be enhanced with an introduction to the city in photos and video.

OPENING CEREMONY: SCHEDULE OF EVENTS

Welcome to ISMP 2015
François Margot, Conference Chair

MOS Chair's Message
William Cook, Chair
Mathematical Optimization Society

Awarding of Prizes

- Paul Y. Tseng Memorial Lectureship in Continuous Optimization – for outstanding contributions in continuous optimization. Presentation by committee chair Yinyu Ye.
- A. W. Tucker Prize – for an outstanding thesis in mathematical programming. Announcement and presentation of finalists by committee chair Karen Aardal.
- Lagrange Prize in Continuous Optimization – for outstanding work in continuous optimization. Sponsored jointly by MOS and the Society for Industrial and Applied Mathematics. Presentation by committee chair Mihai Anitescu.
- Beale-Orchard-Hays Prize – for outstanding work in computational mathematical programming. Presentation by committee chair Robert Bixby.
- Delbert Ray Fulkerson Prize – for outstanding papers in discrete mathematics. Sponsored jointly by MOS and the American Mathematical Society. Presentation by committee chair Michele Conforti.
- George B. Dantzig Prize – for original research having a major impact on mathematical optimization. Sponsored jointly by MOS and the Society for Industrial and Applied Mathematics. Award presentation by committee chair Margaret Wright.

THANK YOU

GAMS

Opening Ceremony and Reception

CONFERENCE CRUISE & BANQUET

Wednesday, July 15
6:50pm-10:00pm

6:50pm: Meet in the Wyndham lobby for the guided walk across Point State Park to the riverboat landing.

The city of Pittsburgh is defined by its rivers, set on a "Golden Triangle" of land where the Allegheny and Monongahela Rivers meet to form the Ohio. Our conference banquet will be held aboard two Gateway Clipper riverboats, the Empress and the Duchess, which will be joined together so you can move easily between the two. The cruise will offer panoramic views of the Pittsburgh skyline and surrounding landscape.

We are proud to introduce you to some local craft beers, and you'll enjoy a hearty buffet dinner. The dinner will include:

- Seared petite flat iron steak with steak Diane sauce
- Almond crusted Atlantic cod filet with a bique style romesco sauce
- Vegetarian lasagna
- Choice of Caesar salad or baby spinach salad
- Vegetable medley, parsley potatoes, penne pasta with tomato basil sauce
- Choice of apple nut cake or chocolate fudge cake
- Wine, coffee, tea

THANK YOU

Carnegie Mellon Tepper SCHOOL OF BUSINESS

Conference Cruise and Banquet

EVENING SCHEDULE

We'll board the riverboat at Point State Park, just across the street from the Wyndham Hotel. Please follow this time schedule – the boat will depart promptly at 7:30pm. Please remember to bring your ticket.

- 6:50pm – Meet in the Wyndham Hotel lobby for the walk across Point State Park. Guides will lead you to the riverboat landing.
- 7:00-7:30pm – Boarding. Waiters will serve local beers and wine as you board the boat.
- 7:30pm – Boat departs promptly at 7:30.
- 7:30-10:00pm – Cruise around the city, hors d'oeuvres with beer and wine, buffet dinner, musical entertainment.
- 10:00pm – Boat returns to Point State Park landing. Guides will lead you back to the Wyndham.

If you purchased a ticket for the cruise and banquet in advance, your ticket(s) is in your registration envelope. A limited number of tickets may still be available. Check at the ISMP Registration Desk. Tickets are $75 for students and $95 for all other attendees.

MONDAY

PLENARY

9:00am-9:50am
Grand Ballroom 1 & 2

Matroid Minors Project
Jim Geelen
University of Waterloo
Canada

Over the past 15 years I have been working with Bert Gerards and Geoff Whittle on extending the Graph Minors Project, of Paul Seymour and Neil Robertson, to minor-closed classes of representable matroids. This talk is intended to be a gentle overview of our project, covering the main results and some applications in coding theory. No prior exposure to matroid theory is assumed.

Jim Geelen completed his PhD at the University of Waterloo. After three short postdoctoral fellowships at CWI (Amsterdam), RIMS (Kyoto), and ZPR (Cologne), he returned to the University of Waterloo. For the past 15 years he, together with Bert Gerards and Geoff Whittle, has been working on extending the graph minors project to binary matroids.

SEMI-PLENARY

4:35pm-5:25pm
Grand Ballroom 1

Equilibrium Routing Under Uncertainty
Roberto Cominetti
Universidad de Chile
Chile

In this talk we review several alternative models that have been used to describe traffic in congested networks, both in urban transport and telecommunications. We focus on situations where travel times are subject to random fluctuations and how this variability affects the traffic flows. We consider both atomic and non-atomic equilibrium models, and we discuss a class of adaptive dynamics that describe the behavior of agents and which provides a plausible micro-foundation for the emergence of equilibrium. We also discuss some recent ideas on how risk aversion to random travel times might be incorporated in the models. In our presentation we use convex optimization to provide a unifying framework for the different concepts of equilibrium.

Roberto Cominetti graduated as Mathematical Engineer from Universidad de Chile in 1986 and received a PhD in Applied Mathematics from Université Blaise Pascal (Clermontt II) in 1989. He has developed his career at the University of Chile, first at the Department of Mathematical Engineering and more recently at the Department of Industrial Engineering. His main research interests are in convex optimization and algorithmic game theory as well as their applications to equilibrium and dynamics in transportation networks.

SEMI-PLENARY

4:35pm-5:25pm
Grand Ballroom 2

Complexity, Approximation, and Relaxation of the Power Flow Equations
Pascal van Hentenryck
NICTA
Australia

The design, control, and operation of the power grid, probably the largest and most expansive system ever engineered, require the solving of optimization problems over the steady-state power flow equations. The resulting mixed nonconvex programs are often computationally challenging and increasingly so with the increased stochasticity in generation and load. This talk presents some new complexity results, as well as a number of advances in approximating and relaxing the power flow equations to address emerging applications in power systems, including large-scale power restoration after blackouts, the design of resilient networks, and the integration of renewable generation. Extensive computational results demonstrate some of the benefits of the proposed techniques.

Pascal van Hentenryck received his ScB and PhD from the University of Namur in Belgium. He leads the Optimization Research Group at NICTA and holds a vice-chancellor chair in data-intensive computing at the Australian National University. Prior to his NICTA appointment, he was professor at Brown University for about 20 years. His current research is at the intersection of data science and optimization with applications in energy, logistics, disaster management, and computational social science.

TUESDAY

PLENARY

9:00am-9:50am
Grand Ballroom 1 & 2

Optimization in the Age of Big Data: Sparsity and Robustness at Scale
Laurent El Ghaoui
University of California-Berkeley
USA

The term "big data" is too often associated with the sole task of applying machine learning analytics to large data sets. It seems that optimization has been concerned with large data sets for a long time already, not just as purveyor of algorithms for analytics but also as models for decision-making. What is changing in the interface between learning and decision-making? What is the impact of big data on optimization? I will present various approaches and perspectives stemming from the application of optimization models in a big data context. The talk will focus on sparsity and robustness, both in statistical learning and decision-making problems. Some case studies involving online retail problems, finance and energy resource management will be presented. The emerging picture is that of an ever closer integration between the two fields, at both practical and fundamental levels.

Laurent El Ghaoui graduated from Ecole Polytechnique (Palaiseau, France) in 1985, and obtained his PhD in Aeronautics and Astronautics at Stanford University in 1990. He taught at several institutions in France, including Ecole Polytechnique, before joining the EECS department at UC Berkeley in 1999. His research interests include robust optimization, large-scale machine learning, with a focus on text analytics.

SEMI-PLENARY

4:35pm-5:25pm
Grand Ballroom 1

A Gentle, Geometric Introduction to Copositive Optimization
Samuel A. Burer
University of Iowa
USA

This talk illustrates the fundamental connection between nonconvex quadratic optimization and copositive optimization—a connection that allows the reformulation of nonconvex quadratic problems as convex ones in a unified way. We focus on examples having just a few variables or a few constraints for which the quadratic problem can be formulated as a copositive-style problem, which itself can be recast in terms of linear, second-order-cone, and semidefinite optimization. A particular highlight is the role played by the geometry of the feasible set.

Sam Burer is Professor and Tippie Research Fellow in the Department of Management Sciences at the University of Iowa. He received his PhD from the Georgia Institute of Technology, and his research and teaching interests include convex optimization, mixed integer nonlinear programming, operations research, and management sciences. His research has been supported by grants from the National Science Foundation, and he serves on the editorial board of *Operations Research, SIAM Journal on Optimization, Mathematics of Operations Research*, and *Optima*. He also serves as a Council Member of the Mathematical Optimization Society, and as a Member of the Board of Directors of the INFORMS Computing Society.

SEMI-PLENARY

4:35pm-5:25pm
Grand Ballroom 2

Fast Distributed Algorithms for Multi-Agent Optimization
Asu Özdaglar
Massachusetts Institute of Technology
USA

Motivated by today's data processing needs over large networks with local collection and processing of information, we consider a multi agent optimization problem where a network of agents collectively solves a global optimization problem with the objective function given by the sum of locally known convex functions. We present new distributed algorithms drawing on two different approaches: The first is based on Alternating Direction Method of Multipliers (ADMM), which is a classical method for sequentially decomposing optimization problems with coupled constraints. We show that convergence rate of distributed ADMM-based algorithms is O(1/k) (where k is the iteration number), which is faster than the O(1/sqrt(k)) rate of subgradient-based methods, and highlight the dependence on the network structure. The second approach develops an incremental Newton (IN) method, which accesses problem data sequentially. Under strong convexity of local objective functions, a gradient growth condition, and with proper stepsize rules, we show that convergence rate of the IN method is linear.

Asu Özdaglar received the B.S. degree in electrical engineering from the Middle East Technical University, Turkey, in 1996, and the S.M. and Ph.D. degrees in electrical engineering and computer science from the Massachusetts Institute of Technology, in 1998 and 2003 respectively. She is currently a professor in the Electrical Engineering and Computer Science Department at MIT and director of the Laboratory for Information and Decision Systems. Her research expertise includes optimization theory, with emphasis on nonlinear programming and convex analysis, game theory, with applications in communication, social, and economic networks, distributed optimization and control, and network analysis with special emphasis on contagious processes, systemic risk and dynamic control. She is the recipient of a Microsoft fellowship and many awards, including the MIT Graduate Student Council Teaching award, the NSF Career award, the 2008 Donald P. Eckman award of the American Automatic Control Council, and the inaugural Steven and Renee Innovation Fellowship.

WEDNESDAY

PLENARY

9:00am-9:50am
Grand Ballroom 1 & 2

Coordinate Descent Algorithms
Stephen J. Wright
University of Wisconsin-Madison
USA

Coordinate descent algorithms solve optimization problems by successively searching along coordinate directions or coordinate hyperplanes. They have been used in applications for many years, and their popularity continues to grow because of their usefulness in data analysis, machine learning, and other areas of current interest. This talk will describe the fundamentals of the coordinate descent approach, together with its variants and extensions. Convergence properties will be described, mostly with reference to convex objectives. We pay particular attention to a certain problem structure that arises commonly in machine learning applications, showing that efficient implementations of accelerated coordinate descent algorithms are possible for such structures. We also describe parallel variants and discuss their convergence properties under several models of parallel execution.

Stephen Wright received a B.Sc.(Hons) degree in 1981 and a PhD in 1984 from the University of Queensland. He has held appointments at the University of Arizona, North Carolina State University, Argonne National Laboratory (during the 1990s), and the University of Chicago. Since 2001 he has been at the University of Wisconsin-Madison. His research is in continuous optimization and its applications to all areas of science and engineering.

SEMI-PLENARY

4:35pm-5:25pm
Grand Ballroom 1

A Geometric Approach to Cut-Generating Functions
Michele Conforti
University of Padova
Italy

The cutting-plane approach to integer programming was initiated more than 40 years ago: Gomory introduced the corner polyhedron as a relaxation of a mixed integer set in tableau form and Balas introduced intersection cuts for the corner polyhedron. This line of research was left dormant for several decades until relatively recently, when a paper of Andersen, Louveaux, Weismantel and Wolsey generated renewed interest in the corner polyhedron and intersection cuts. Recent developments rely on tools drawn from convex analysis, geometry and number theory, and constitute an elegant bridge between these areas and integer programming. We survey these results and highlight recent breakthroughs in this area.

Michele Conforti received his BS from University of Bologna and a PhD from Carnegie Mellon University. He is currently professor in the Mathematics Department, University of Padova. His interests are mainly in combinatorial optimization and graph theory. He is co-recipient of the Fulkerson Prize. In the past years he has worked in integer programming and has recently co-authored a book on the subject.

SEMI-PLENARY

4:35pm-5:25pm
Grand Ballroom 2

Optimization Challenges in Tensor Factorization
Tamara G. Kolda
Sandia National Laboratories
USA

Tensors are multiway arrays, and tensor decomposition is a powerful tool for compression and data interpretation. In this talk, we demonstrate the utility of tensor decomposition with several examples and explain the optimization challenges, both theoretical and practical. The optimization problems are nonconvex, but they can typically be solved via an alternating approach that yields convex subproblems. We consider open problems such as determining the model complexity, tensor completion, incorporating symmetries and other constraints, handling ambiguities in scaling and permutation, enforcing structure like sparsity, and considering alternative objective functions.

Tamara G. Kolda is a Distinguished Member of the Technical Staff at Sandia National Laboratories in Livermore, California. Her research interests include multilinear algebra and tensor decompositions, graph models and algorithms, data mining, optimization, nonlinear solvers, parallel computing and the design of scientific software. She received her PhD from the University of Maryland in 1997 and was the Oak Ridge National Lab Householder Postdoc in Scientific Computing from 1997-99.

TSENG MEMORIAL LECTURE

5:30pm-6:20pm
Grand Ballroom 1

Paul Y. Tseng Memorial Lecture in Continuous Optimization
The 2015 recipient of the Tseng Memorial Lectureship will be announced at the opening ceremony on Sunday evening. The honoree will make a presentation at this special session on Wednesday. The Tseng Memorial Lectureship in Continuous Optimization was established in 2011 and presented for the first time at ISMP 2012. The lectureship commemorates the outstanding contributions of Professor Tseng in continuous optimization and promotes research and applications in the Asia-Pacific region. The lectureship is awarded to an individual for outstanding contributions in continuous optimization, consisting of original theoretical results, innovative applications, or successful software development.

THURSDAY

PLENARY

9:00am-9:50am
Grand Ballroom 1 & 2

A Distributionally Robust Perspective on Uncertainty Quantification and Chance Constrained Programming

Daniel Kuhn
Ecole Polytechnique Fédérale de Lausanne
Switzerland

The objective of uncertainty quantification is to certify that a given physical, engineering or economic system satisfies multiple safety conditions with high probability. A more ambitious goal is to actively influence the system so as to guarantee and maintain its safety, a scenario which can be modeled through a chance constrained program. In this talk we assume that the parameters of the system are governed by an ambiguous distribution that is only known to belong to an ambiguity set characterized through generalized moment bounds and structural properties such as symmetry, unimodality or independence patterns. We delineate the watershed between tractability and intractability in ambiguity-averse uncertainty quantification and chance constrained programming. Using tools from distributionally robust optimization, we derive explicit conic reformulations for tractable problem classes and suggest efficiently computable conservative approximations for intractable ones.

Daniel Kuhn holds the Chair of Risk Analytics and Optimization at EPFL. Before joining EPFL, he was a faculty member at Imperial College London (2007-2013) and a postdoctoral researcher at Stanford University (2005-2006). He received a PhD in Economics from the University of St. Gallen in 2004 and an MSc in Theoretical Physics from ETH Zurich in 1999. His research interests revolve around robust optimization and stochastic programming.

SEMI-PLENARY

4:35pm-5:25pm
Grand Ballroom 1

On Mathematical Programming with Indicator Constraints

Andrea Lodi
University of Bologna
Italy

In this paper we review the relevant literature on mathematical optimization with logical implications, i.e., where constraints can be either active or disabled depending on logical conditions to hold. In the case of convex functions, the theory of disjunctive programming allows one to formulate these logical implications as convex nonlinear programming problems in a space of variables lifted with respect to its original dimension. We concentrate on the attempt of avoiding the issue of dealing with large NLPs. In particular, we review some existing results that allow to work in the original space of variables for two relevant special cases where the disjunctions corresponding to the logical implications have two terms. Then, we significantly extend these special cases in two different directions, one involving more general convex sets and the other with disjunctions involving three terms. Computational experiments comparing disjunctive programming formulations in the original space of variables with straightforward big M ones show that the former are computationally viable and promising. (Joint work with Pierre Bonami, Andrea Tramontani and Sven Wiese).

Andrea Lodi received the PhD in System Engineering from the University of Bologna in 2000 and he has been Herman Goldstine Fellow at the IBM Mathematical Sciences Department, NY in 2005–2006. He is full professor of Operations Research at DEI, University of Bologna since 2007. His main research interests are in mixed-integer linear and nonlinear programming. He is author of more than 70 publications in the top journals of the field of mathematical programming. He serves as Associate Editor for several prestigious journals in the area and is currently network coordinator of two large EU projects, and, since 2006, consultant of the IBM CPLEX research and development team.

SEMI-PLENARY

4:35pm-5:25pm
Grand Ballroom 2

Quasi-Monte Carlo Methods for Linear Two-Stage Stochastic Programming Problems

Werner Römisch
Humboldt-Universität Berlin
Germany

Quasi-Monte Carlo algorithms are studied for generating scenarios to solve two-stage linear stochastic programming problems. Their integrands are piecewise linear-quadratic, but do not belong to the function spaces considered for QMC error analysis. We show that under some weak geometric condition on the two-stage model all terms of their ANOVA decomposition, except the one of highest order, are continuously differentiable and second order mixed derivatives exist almost everywhere and belong to L_{2}. This implies that randomly shifted lattice rules may achieve the optimal rate of convergence $O(n^{-1+\delta})$ with $\delta\in(0,\frac{1}{2})$ and a constant not depending on the dimension if the effective superposition dimension is less than or equal to two. The geometric condition is shown to be satisfied for almost all covariance matrices if the underlying probability distribution is normal. We discuss effective dimensions and techniques for dimension reduction. Numerical experiments for a production planning model with normal inputs show that indeed convergence rates close to the optimal rate are achieved when using randomly shifted lattice rules or scrambled Sobol' point sets accompanied with principal component analysis for dimension reduction.

Werner Römisch received a mathematics diploma in 1971 and a PhD in 1976 both from Humboldt-University Berlin. He continued at Humboldt-University Berlin and received there a habilitation in 1985 and a full professorship in 1993. His research is mainly in stochastic optimization with side interests in stochastic equations and risk, and applications in energy and revenue management.

FRIDAY

PLENARY

9:00am-9:50am
Grand Ballroom 1 & 2

Laplacian Matrices of Graphs: Algorithms and Applications

Daniel A. Spielman
Yale University
USA

The problem of solving systems of linear equations in the Laplacian matrices of graphs arises in many fields including optimization, machine learning, computer vision, and of course computational science. We will explain what these matrices are and why they arise in so many applications. We then will survey recently developed algorithms that allow us to solve such systems of linear equations in nearly-linear time. The main tools used in these algorithms are sparse approximations of graphs and approximations of graphs by low-stretch spanning trees. The ability to quickly solve such systems of equations has led to the asymptotically fastest algorithms for computing maximum flows and minimum cost flows. The techniques used in the Laplacian equation solvers have been used to design the fastest algorithms for approximating maximum flows. We will provide an introduction to these recent developments.

Daniel Alan Spielman received a B.A. in Mathematics and Computer Science from Yale in 1992 and a PhD in Applied Mathematics from M.I.T. in 1995. He spent a year as a NSF Mathematical Sciences Postdoc in the Computer Science Department at U.C. Berkeley, and then taught in the Applied Mathematics Department at M.I.T. until 2005. Since 2006, he has been a Professor of Computer Science and Mathematics at Yale University. He has received many awards, including the 1995 ACM Doctoral Dissertation Award, the 2002 IEEE Information Theory Paper Award, the 2008 Godel Prize, the 2009 Fulkerson Prize, the 2010 Nevanlinna Prize, the 2014 Polya Prize, an inaugural Simons Investigator Award, and a MacArthur Fellowship. His main research interests include the design and analysis of algorithms, network science, machine learning, digital communications and scientific computing.

SEMI-PLENARY

4:35pm-5:25pm
Grand Ballroom 1

Mathematical Optimization for Packing Problems

Frank Vallentin
University of Köln
Germany

How densely can one pack given objects into a given container? Such packing problems are fundamental problems in geometric optimization. Next to being classical mathematical challenges there are many applications in diverse areas such as information theory, materials science, physics, logistics, approximation theory. Studying packing problems, one is facing two basic tasks: Constructions: How to construct packings which are conjecturally optimal? Obstructions: How to prove that a given packing is indeed optimal? For the first basic task researchers in mathematics and engineering found many heuristics which often work well in practice. In the talk I will explain computational tools for the second basic task. These tools are a blend of tools coming from infinite-dimensional semidefinite optimization and harmonic analysis, together with computational techniques coming from real algebraic geometry and polynomial optimization. I will report on computational results, which are frequently the best-known.

Frank Vallentin is a professor of applied mathematics and computer science at Universität zu Köln. In 2003 he received his PhD in mathematics from Technische Universität München. Past appointments include assistant and associate professor at Technische Universiteit Delft, postdoc at Centrum Wiskunde & Informatica in Amsterdam and postdoc at the Hebrew University of Jerusalem. His research interests include optimization, geometry, discrete and experimental mathematics.

SEMI-PLENARY

4:35pm-5:25pm
Grand Ballroom 2

Recent Advances in Trust-Region Algorithms

Ya-xiang Yuan
Chinese Academy of Sciences
China

Trust-region methods are a class of numerical methods for optimization. Unlike line search type methods where a line search is carried out in each iteration, trust-region methods compute a trial step by solving a trust-region subproblem where a model function is minimized within a trust region. Due to the trust-region constraint, nonconvex models can be used in trust-region subproblems, and trust-region algorithms can be applied to nonconvex and ill-conditioned problems. Normally it is easier to establish the global convergence of a trust-region algorithm than that of its line search counterpart. In the paper, we review recent results on trust-region methods for unconstrained optimization, constrained optimization, nonlinear equations and nonlinear least squares, nonsmooth optimization and optimization without derivatives. Results on trust-region subproblems and regularization methods are also discussed.

Ya-xiang Yuan received a BSc from Xiangtan University (China) in 1981 and a PhD from University of Cambridge (UK) in 1986. He was Rutherford Fellow at Fitzwilliam College, University of Cambridge from 1985-1988. He returned to China in 1988, and has been working as a full professor at the Chinese Academy of Sciences since then. His research area is mainly in continuous optimization, particularly on trust region methods, quasi-Newton methods, nonlinear conjugate gradients, and subspace methods.

EXHIBIT AREA

Grand Ballroom Foyer

EXHIBIT HOURS

Monday, 9:00am-5:30pm

Tuesday, 9:00am-5:30pm

Wednesday, 9:00am-4:45pm

COFFEE BREAKS

Grand Ballroom Foyer

Morning: 9:50am-10:20am

Afternoon: 4:15pm-4:35pm

SOFTWARE TUTORIALS

Several exhibitors will also present software tutorials in the technical program:

Monday, July 13, Track 12

10:20am-11:00am Mosek ApS

1:10pm-1:50pm SAS

2:45pm-3:25pm Do Analytics

Tuesday, July 14, Track 12

10:20am-11:00am AMPL Optimization, Inc.

AMPL
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SAS Institute Inc.
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Track	Room	Plenary 9:00am - 9:50am	MB 10:20am - 11:50am	MC 1:10pm - 2:40pm	MD 2:45pm - 4:15pm	Semi-Plenaries 4:35pm-5:25pm	MF 5:30pm - 7:00pm
1	Grand Ballroom 1	Plenary Jim Geelen Grand Ballroom 1 & 2	The A.W. Tucker Prize	Nonsmooth Optimization	Variational Analysis	Semi-Plenary Presentations Roberto Cominetti Ballroom I Pascal van Hentenryck Ballroom 2	Variational Analysis
2	Grand Ballroom 2		Complementarity	Optimization in Energy Systems	Optimization in Energy Systems		Opt. in Energy Systems
3	Grand Ballroom 3		Combinatorial Optimization	Approx.Algorithms for Clustering Problems	Combinatorial Optimization		Combinatorial Optimization
4	Grand Ballroom 4		Conic Programming	Conic Programming	Conic Programming		Conic Programming
5	Kings Garden 1		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming		Nonlinear Programming
6	Kings Garden 2		Optimization in Energy Systems	Optimization in Energy Systems	Telecommunications and Networks		Telecommunications and Networks
7	Kings Garden 3		Implementations and Software	Implementations and Software	Sparse Optimization and Applications		Nonsmooth Optimization
8	Kings Garden 4		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization		Combinatorial Optimizatio
9	Kings Garden 5		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization		Combinatorial Optimization
10	Kings Terrace		No Sessoin	Logistics Traffic and Transportation	Logistics Traffic and Transportation		Logistics Traffic and Transportation
11	Brigade		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization		Combinatorial Optimization
12	Black Diamond		Software Presentations MOSEK	Software Presentations SAS	Software Presentations OPTEX Math. Modeling System		No Session
13	Rivers		Conic Programming	Conic Programming	Conic Programming		Conic Programming
14	Traders		Game Theory	Game Theory	Game Theory		Game Theory
15	Chartiers		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming		Implementations and Software
16	Sterlings 1		Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming		Integer and Mixed-Integer Programming
17	Sterlings 2		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming		Nonlinear Programming
18	Sterlings 3		Stochastic Optimization	Stochastic Optimization	Stochastic Optimization		Stochastic Optimization
19	Ft. Pitt		PDE-Constrained Optimization and Multi-Level	PDE-Constrained Optimization	PDE-Constrained Optimization		Multi-Objective Optimization
20	Smithfield		Nonsmooth Optimization	Nonsmooth Optimization	Nonsmooth Optimization		Nonsmooth Optimization
21	Birmingham		Telecommunications and Networks	Derivative-Free and Simulation-Based Optimization	Derivative-Free and Simulation-Based Optimization		Derivative-Free and Simulation-Based Optimization
22	Heinz		Global Optimization	Global Optimization	Global Optimization		Global Optimization
23	Allegheny		Robust Optimization	Robust Optimization	Robust Optimization		Robust Optimization
24	Benedum		Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming		Multi-Objective Optimization
25	Board Room		Constraint Programming	Constraint Programming	Constraint Programming		Life Sciences and Healthcare
26	Forbes Room		Finance and Economics	Finance and Economics	Finance and Economics		Stochastic Optimization
27	Duquesne Room		Sparse Optimization and Applications	Sparse Optimization and Applications	Sparse Optimization and Applications		Optimization in Energy Systems
28	Liberty Room		Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming		Complementarity/Variational Inequality/Related Problems
29	Commonwealth 1		Nonsmooth Optimization	Nonsmooth Optimization	Nonsmooth Optimization		Nonsmooth Optimization
30	Commonwealth 2		Approximation and Online Algorithms	Approximation and Online Algorithms	Approximation and Online Algorithms		Approximation and Online Algorithms

TUESDAY TRACK SCHEDULE

Track	Room	Plenary 9:00am - 9:50am	TB 10:20am - 11:50am	TC 1:10pm - 2:40pm	TD 2:45pm - 4:15pm	Semi-Plenaries 4:35pm-5:25pm
1	Grand Ballroom 1	Plenary Laurent El Ghaoui Grand Ballroom 1 & 2	Variational Analysis	Implementations and Software	Implementations and Software	Semi-Plenary Presentations Samual Burer Grand Ballroom I Asu Özdaglar Grand Ballroom 2
2	Grand Ballroom 2		Optimization in Energy Systems	Optimization in Energy Systems	Optimization in Energy Systems	
3	Grand Ballroom 3		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization	
4	Grand Ballroom 4		Conic Programming	Conic Programming	Conic Programming	
5	Kings Garden 1		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming	
6	Kings Garden 2		Telecommunications and Networks	Telecommunications and Networks	Telecommunications and Networks	
7	Kings Garden 3		Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	
8	Kings Garden 4		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization	
9	Kings Garden 5		Combinatorial Optimization	Combinatorial Optimization	Robust Optimization	
10	Kings Terrace		Finance and Economics	Finance and Economics	Finance and Economics	
11	Brigade		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization	
12	Black Diamond		Software Presentations AMPL	No Session	Logistics Traffic and Transportation	
13	Rivers		Conic Programming	Conic Programming	Conic Programming	
14	Traders		Game Theory	Game Theory	Game Theory	
15	Chartiers		PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods	PDE-Constrained Optimization Methods	PDE-Constrained Optimization and Multi-Level	
16	Sterlings 1		Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	
17	Sterlings 2		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming	
18	Sterlings 3		Stochastic Optimization	Stochastic Optimization	Conic Programming	
19	Ft. Pitt		Constraint Programming	Constraint Programming	Constraint Programming	
20	Smithfield		Nonsmooth Optimization	Nonsmooth Optimization	Nonsmooth Optimization	
21	Birmingham		Derivative-Free and Simulation-Based Optimization	Derivative-Free and Simulation-Based Optimization	Conic Programming	
22	Heinz		Global Optimization	Mixed-Integer Nonlinear Programming	Variational Analysis	
23	Allegheny		Robust Optimization	Sparse Optimization	Sparse Optimization and Applications	
24	Benedum		Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	
25	Board Room		Logistics Traffic and Transportation	Logistics Traffic and Transportation	Optimization in Energy Systems	
26	Forbes Room		Stochastic Optimization	Stochastic Optimization	Stochastic Optimization	
27	Duquesne Room		Optimization in Energy Systems	Optimization in Energy Systems	Optimization in Energy Systems	
28	Liberty Room		Global Optimization	Global Optimization	Global Optimization	
29	Commonwealth 1		Nonsmooth Optimization	Nonsmooth Optimization	Nonsmooth Optimization	
30	Commonwealth 2		Approximation and Online Algorithms	Approximation and Online Algorithms	Approximation and Online Algorithms	

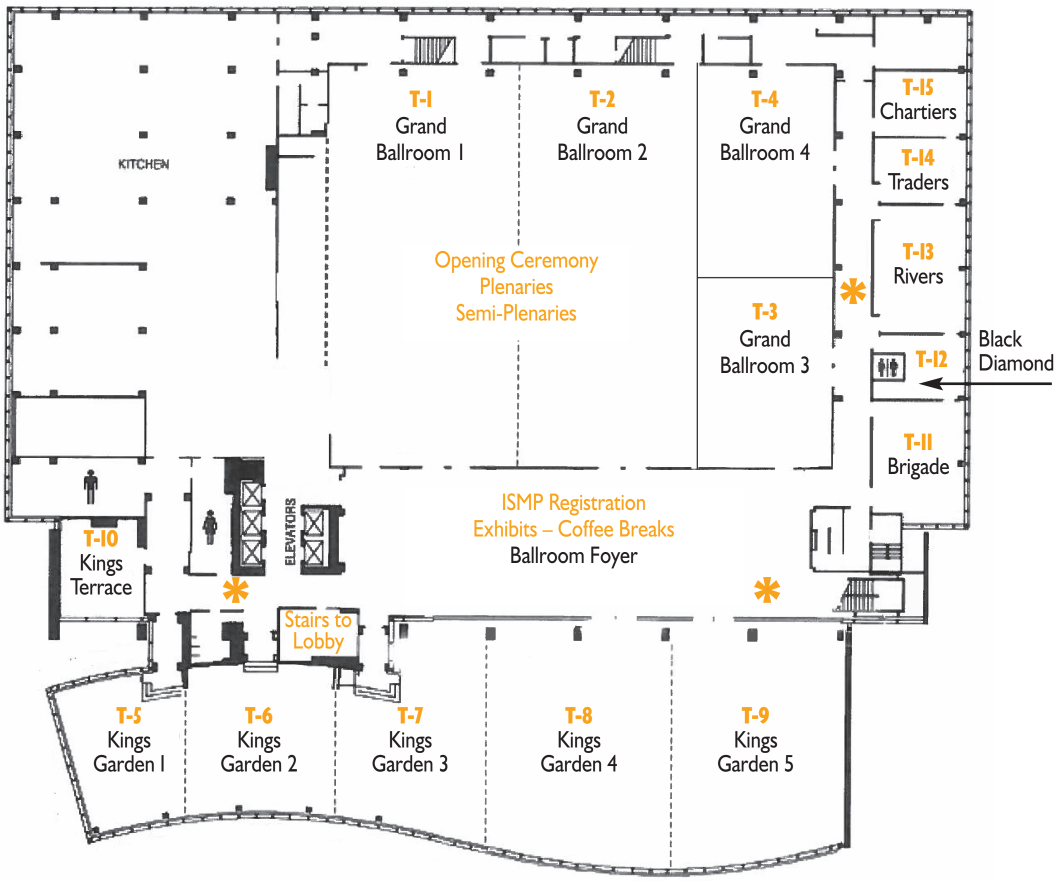
Track	Room	Plenary 9:00am - 9:50am	WB 10:20am - 11:50am	WC 1:10pm - 2:40pm	WD 2:45pm - 4:15pm	Semi-Plenaries
1	Grand Ballroom 1	Plenary Stephen Wright Grand Ballroom 1 & 2	Implementations and Software	Implementations and Software	Complementarity/Variational Inequality/Related Problems	4:35pm-5:25pm Semi-Plenary Presentations Michele Conforti Grand Ballroom 1 Tamara G. Kolda Grand Ballroom 2 5:30-6:20pm Tseng Memorial Lecture Ballroom 1
2	Grand Ballroom 2		Optimization in Energy Systems	Optimization in Energy Systems	Optimization in Energy Systems	
3	Grand Ballroom 3		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization	
4	Grand Ballroom 4		Conic Programming	Conic Programming	Conic Programming	
5	Kings Garden 1		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming	
6	Kings Garden 2		Telecommunications and Networks	Telecommunications and Networks	Telecommunications and Networks	
7	Kings Garden 3		Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	
8	Kings Garden 4		Combinatorial Optimization	Combinatorial Optimization	Life Sciences and Healthcare	
9	Kings Garden 5		Robust Optimization	Robust Optimization	Robust Optimization	
10	Kings Terrace		Finance and Economics	Stochastic Optimization	Finance and Economics	
11	Brigade		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization	
12	Black Diamond		Logistics Traffic and Transportation	Logistics Traffic and Transportation	Logistics Traffic and Transportation	
13	Rivers		Conic Programming	Conic Programming	Conic Programming	
14	Traders		Game Theory	Game Theory	Game Theory	
15	Chartiers		PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods	PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods	No Session	
16	Sterlings 1		Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	
17	Sterlings 2		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming	
18	Sterlings 3		Life Sciences and Healthcare	Integer and Mixed-Integer Programming	Nonlinear Programming	
19	Ft. Pitt		Constraint Programming	Constraint Programming	Constraint Programming	
20	Smithfield		Nonsmooth Optimization	Nonsmooth Optimization	Nonsmooth Optimization	
21	Birmingham		Multi-Objective Optimization	Multi-Objective Optimization	Derivative-Free and Simulation-Based Optimization	
22	Heinz		Variational Analysis	Variational Analysis	Variational Analysis	
23	Allegheny		Sparse Optimization and Applications	Sparse Optimization and Applications	Multi-Objective Optimization	
24	Benedum		Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	
25	Board Room		Optimization in Energy Systems	Optimization in Energy Systems	Optimization in Energy Systems	
26	Forbes Room		Stochastic Optimization	Stochastic Optimization	Stochastic Optimization	
27	Duquesne Room		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization	
28	Liberty Room		Global Optimization	Global Optimization	Global Optimization	
29	Commonwealth 1		Nonsmooth Optimization	Nonsmooth Optimization	Nonsmooth Optimization	
30	Commonwealth 2		Approximation and Online Algorithms	Approximation and Online Algorithms	Approximation and Online Algorithms	

THURSDAY TRACK SCHEDULE

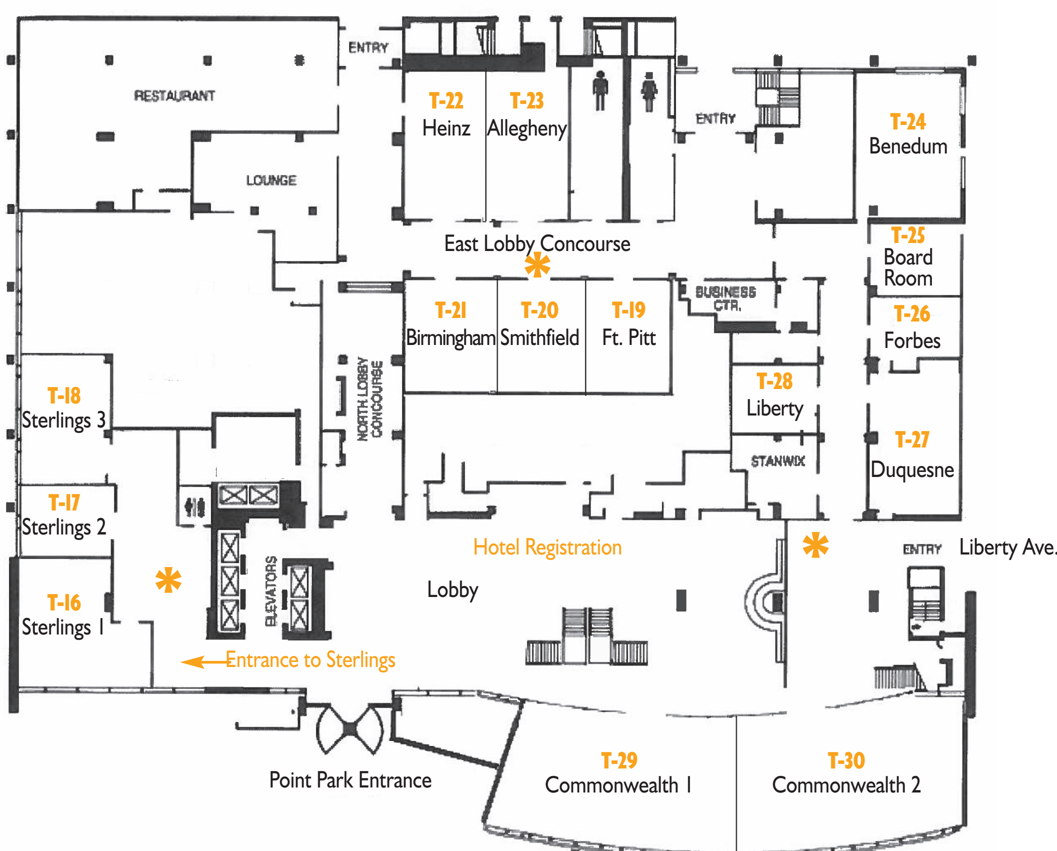
Track	Room	Plenary 9:00am - 9:50am	ThB 10:20am - 11:50am	ThC 1:10pm - 2:40pm	ThD 2:45pm - 4:15pm	Semi-Plenaries 4:35pm-5:25pm	ThF 5:30pm - 7:00pm
1	Grand Ballroom 1	Plenary Daniel Kuhn-- Grand Ballroom I & 2	Complementarity/Variational Inequality/Related Problems	Complementarity/Variational Inequality/Related Problems	Complementarity/Variational Inequality/Related Problems	Semi-Plenary Presentations Andrea Lodi Grand Ballroom I Werner Römisch Grand Ballroom 2	Complementarity/Variational Inequality/Related Problems
2	Grand Ballroom 2		Optimization in Energy Systems	Optimization in Energy Systems	Optimization in Energy Systems		Conic Programming
3	Grand Ballroom 3		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization		Combinatorial Optimization
4	Grand Ballroom 4		Conic Programming	Conic Programming	Conic Programming		Conic Programming
5	Kings Garden 1		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming		Nonlinear Programming
6	Kings Garden 2		Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	Integer and Mixed-Integer Programming		Integer and Mixed-Integer Programming
7	Kings Garden 3		Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming		Integer and Mixed-Integer Programming
8	Kings Garden 4		Sparse Optimization and Applications	Sparse Optimization and Applications	Sparse Optimization and Applications		Sparse Optimization and Applications
9	Kings Garden 5		Robust Optimization	Robust Optimization	Robust Optimization		Robust Optimization
10	Kings Terrace		Life Sciences and Healthcare	Finance and Economics	Finance and Economics		Nonlinear Programming
11	Brigade		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization		Combinatorial Optimization
12	Black Diamond		No Session	Logistics Traffic and Transportation	Logistics Traffic and Transportation		No Session
13	Rivers		Conic Programming	Game Theory	Conic Programming		Conic Programming
14	Traders		Stochastic Optimization	Game Theory	Game Theory		Game Theory
15	Chartiers		Implementations and Software	Implementations and Software	Global Optimization		Global Optimization
16	Sterlings 1		Integer and Mixed-Integer Programming	Telecommunications and Networks	Stochastic Optimization		Stochastic Optimization
17	Sterlings 2		Game Theory	Nonlinear Programming	Life Sciences and Healthcare		Life Sciences and Healthcare
18	Sterlings 3		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming		Nonlinear Programming
19	Ft. Pitt		Constraint Programming	Constraint Programming	Combinatorial Optimization		Game Theory
20	Smithfield		Nonsmooth Optimization	Nonsmooth Programming	Nonsmooth Optimization		Nonsmooth Optimization
21	Birmingham		Derivative-Free and Simulation-Based Optimization	Derivative-Free and Simulation-Based Optimization	Derivative-Free and Simulation-Based Optimization		Implementations & Software
22	Heinz		Variational Analysis	Variational Analysis	Variational Analysis		Logistic Traffic & Transportation
23	Allegheny		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization		Combinatorial Optimization
24	Benedum		Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming		Mixed-Integer Nonlinear Programming
25	Board Room		Optimization in Energy Systems	Optimization in Energy Systems	Optimization in Energy Systems		Optimization in Energy Systems
26	Forbes Room		No Session	Stochastic Optimization	Stochastic Optimization		Stochastic Optimization
27	Duquesne Room		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization		Combinatorial Optimization
28	Liberty Room		Global Optimization	Telecommunications and Networks	Telecommunications and Networks		Telecommunications and Networks
29	Commonwealth 1		Nonsmooth Optimization	Nonsmooth Optimization	Nonsmooth Optimization		Implementations & Software
30	Commonwealth 2		Approximation and Online Algorithms	Approximation and Online Algorithms	Approximation and Online Algorithms		Approximation and Online Algorithms

Track	Room	Plenary 9:00am - 9:50am	FB 10:20am - 11:50am	FC 1:10pm - 2:40pm	FD 2:45pm - 4:15pm	Semi-Plenaries 4:35pm-5:25pm
1	Grand Ballroom 1	Plenary Daniel Spielman Grand Ballroom 1 & 2	Complementarity	Complementarity	Integer and Mixed-Integer Programming	Semi-Plenary Presentations Frank Vallentin Grand Ballroom 1 Ya-xiang Yuan Grand Ballroom 2
2	Grand Ballroom 2		Conic Programming	Conic Programming	Conic Programming	
3	Grand Ballroom 3		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization	
4	Grand Ballroom 4		Conic Programming	Multi-Objective Optimization	Conic Programming	
5	Kings Garden 1		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming	
6	Kings Garden 2		Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	Integer and Mixed-Integer Programming	
7	Kings Garden 3		Variational Analysis	PDE-Constrained Optimization	Telecommunications and Networks	
8	Kings Garden 4		Sparse Optimization and Applications	Sparse Optimization and Applications	Sparse Optimization and Applications	
9	Kings Garden 5		Robust Optimization	Nonsmooth Optimization	Nonlinear Programming	
10	Kings Terrace		Finance and Economics	Finance and Economics	Finance and Economics	
11	Brigade		Logistics Traffic and Transportation	Combinatorial Optimization	Global Optimization	
12	Black Diamond		No Session	No Session	No Session	
13	Rivers		Conic Programming	Constraint Programming	Nonsmooth Optimization	
14	Traders		Game Theory	Game Theory	No Session	
15	Chartiers		Global Optimization	Combinatorial Optimization	No Session	
16	Sterlings 1		Stochastic Optimization	Stochastic Optimization	Stochastic Optimization	
17	Sterlings 2		Life Sciences and Healthcare	Life Sciences and Healthcare	Multi-Objective Optimization	
18	Sterlings 3		Nonlinear Programming	Nonlinear Programming	Nonlinear Programming	
19	Ft. Pitt		Game Theory	Derivative-Free and Simulation-Based	Logistics Traffic and Transportation	
20	Smithfield		Nonsmooth Optimization	Logistics Traffic and Transportation	Life Sciences and Healthcare	
21	Birmingham		Optimization in Energy Systems	Optimization in Energy Systems	Optimization in Energy Systems	
22	Heinz		Variational Analysis	Integer and Mixed-Integer Programming	Game Theory	
23	Allegheny		Combinatorial Optimization	Combinatorial Optimization	Combinatorial Optimization	
24	Benedum		Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	
25	Board Room		Optimization in Energy Systems	Optimization in Energy Systems	No Session	
26	Forbes Room		Stochastic Optimization	No Session	No Session	
27	Duquesne Room		Combinatorial Optimization	Combinatorial Optimization	No Session	
28	Liberty Room		Telecommunications and Networks	Telecommunications and Networks	No Session	
29	Commonwealth 1		Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	Mixed-Integer Nonlinear Programming	
30	Commonwealth 2		Approximation and Online Algorithms	Approximation and Online Algorithms	Approximation and Online Algorithms	

BALLROOM LEVEL
Tracks 1-15



LOBBY LEVEL
Tracks 16-30



✱ **Session Monitor Desks**

MB02

Talk #1 Updated

Title: Gradient Sliding Algorithms for Composite Optimization

Presenting Author: Guanghui Lan,University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville FL, United States of America, glan@ise.ufl.edu

Abstract: We present gradient sliding (GS) algorithms for solving composite optimization problems whose objective function consists of the summation of a smooth component with some complicated nonsmooth terms. We show that these GS algorithms can skip the computation of the gradient for the smooth component from time to time while still preserving the overall optimal complexity bounds.

MC23

Late Cancellation Paper # 3

*****LATE CANCELLATION***Data-Driven Distributionally Robust Optimization using the Wasserstein Metric**

Presenting Author: Peyman Mohajerin Esfahani,Dr, EPFL & ETH Zurich, Funkwiesenstrasse 100, Zurich 8050, Switzerland, peyman.mohajerin@epfl.ch

MD 13

Late cancellation paper # 1

*****LATE CANCELLATION***Convex Optimization Learning of Faithful Euclidean Distance Matrices in Dimensionality Reduction**

Presenting Author: Chao Ding,Assistant professor, Chinese Academy of Sciences, No. 55, Zhong Guan Cun Dong Lu, Haidian District

Paper # 2 new presenter

A Schatten p-Norm Perturbation Inequality and Its Applications in Low–Rank Matrix Recovery
Anthony Man-Cho So

MD 15

New Session Chair

Title: Nonlinear Programming - Contributed III

Chair: Minh Pham,Research Associate, SAMSI / Duke University, 19 TW ALEXANDER DR., DURHAM NC 27707, United States of America, ptuanminh@gmail.com

Late Cancellation

*****LATE CANCELLATION***On the Design and Implementation of SQP Methods**
Jose Luis Morales

MD19

Late Cancellation paper #2

*****Late Cancellation***Optimal Placement and Trajectories of Sensor Networks under Constraints**
Carlos Rautenberg

MF05

Late Cancellation Paper #1

*****LATE CANCELLATION***In-Network Nonconvex Optimization**
Lead Author: Gesualdo Scutari

MF26

Late Cancellation Paper #3

*****LATE CANCELLATION***A Note on Complexity of Multistage Stochastic Programs**
Marcus Reaiche

TB10
Late Cancellation Paper #3
*****LATE CANCELLATION***Optimal Expectation Inequalities for Structured Distributions**
Lead Author: Bart Van Parys

TD04
Talk #2 updated
Title: Bypassing Gradiant Computation Through Randomization
Presenting Author: Guanghui Lan,University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville FL, United States of America, glan@ise.ufl.edu

Abstract: We present novel randomized prima-dual gradient (RPDG) methods for minimizing a class of convex optimization problems, whose objective function consists of the the summation of m smooth components, possibly together with some other relatively simple convex terms. We show that the total number of gradient evaluations required by the RPDG method can be $\sqrt{m}$ times smaller, in expectation and with overwhelming probability, than those performed by deterministic optimal first-order methods.

TD12
Late Cancellation
*****LATE CANCELLATION***Computing Equilibrium in the Stable Dynamic Transportation Model**
Yura Dorn

TD13
Late cancellation paper #2
*****LATE CANCELLATION***Strong Symmetric Duality and Simplex Type Algorithm for Continuous Linear Programs**
Evgeny Shindin

TD29
New Session Chair
Title: Recent Advances in ADMM I
Chair: Deren Han,Prof., Nanjing Normal University, Nanjing Normal University,Nanjing,China, Nanjing 210023, China, handeren@njnu.edu.cn
Late Cancellation
*****LATE CANCELLLATION***Block-Wise Alternating Direction Method of Multipliers for Multiple-Block Convex Programming**
Xiaoming Yuan

WB28
Updated abstract #1
Regularization Vs. Relaxation: A Conic Optimization Perspective Of Statistical Variable Selection
Hongbo Dong
Variable selection is a fundamental task in statistical data analysis. Regularization functions, as approximations to the l-0 norm, are typically used to encourage sparsity in the solution. We show that a popular concave penalty function, namely Minimax Concave Penalty (MCP), can be derived from perspective relaxation. A related minimax problem, which balances the overall convexity and tightness of MCP as an approximation to the indicator function, can be solved by a semidefinite relaxation. In light of these results, we argue that conic optimization can be a useful tool to construct methods for variable selection in regression.
WC08
Hilbert's Nullstellensatz Certificates of Infeasibility for Combinatorial Problems
Susan Margulies,Assistant Professor, US Naval Academy, 303 Chauvenet Hall, Annapolis MD, United States of America, margulie@usna.edu
Systems of polynomial equations can be used to compactly and elegantly model combinatorial problems in such a way that if a given combinatorial property is not satisfied, then the system of polynomial

equations has no solution. If a system of polynomial equations has no solution, there exists a very specific algebraic proof of infeasibilty via the famous Hilbert's Nullstellensatz. In this talk we compare and contrast the complexity of Hilbert's Nullstellensatz certificates when the underlying combinatorial problem is NP-complete (such as Partition), as compared to problems known to be in P (such as 2-colorability or Matching).

WC20

New Session Chair
Title: Recent Advances in ADMM II
Chair: Caihua Chen,Dr., Nanjing University, 22 Hankou Road, Nanjing, China, chchen@nju.edu.cn

WC27
Late Cancellation
*****LATE CANCELLATION***A 1.93-Approximation Algorithm for Submodular PCST on Bounded Treewidth Graphs**

WD20
New Session Chair
Title: Recent Advances in ADMM III
Chair: Tingting Wu,Dr., School of Science, Nanjing University of Posts and Telecommunications, #9 Culture Gardens Road, Nanjing, China, Nanjing Al 210023, China, wutt@njupt.edu.cn

ThC01 and FC01
Presentation Swap
Computing B-Stationary Points of Nonsmooth DC Programs - moved from ThC01 to FA01
New presenter **Alberth Alvarado**

A Game-Theoretic Approach to Computation Offloading in Mobile Cloud Computing moved from FA01 to ThC01 Francisco Facchinei

ThC05
Updated abstract #2
Title: Mixed-Integer PDE-Constrained Optimization
Presenting Author: Sven Leyffer,Argonne National Laboratory, 9700 South Cass Ave, Argonne IL, United States of America, leyffer@mcs.anl.gov

Abstract: Many complex applications can be formulated as optimization problems constrained by partial differential equations (PDEs) with integer decision variables. Examples include the remediation of contaminated sites and the maximization of oil recovery; the design of next generation solar cells; the layout design of wind-farms; the design and control of gas networks; disaster recovery; and topology optimization. We will present emerging applications of mixed-integer PDE-constrained optimization, review existing approaches to solve these problems, and highlight their computational and mathematical challenges. We introduce a new set of benchmark set for this challenging class of problems, and present some early numerical experience using both mixed-integer nonlinear solvers and heuristic techniques.

ThC08
Late Cancellation

*****LATE CANCELLATION***Cosparse Image Recovery from Few Tomographic Projections**

Stefania Petra
*****LATE CANCELLATION***Sparse Signal Recovery from Nonlinear Measurements**
Yonina Eldar

ThC28

New Paper moved from FB28

Optimal Design of Switched Ethernet Networks Implementing the Multiple Spanning Tree Protocol

Presenting Author: **Martim Joyce-Moniz**, Université Libre de Bruxelles - Graphes et Optimisation Mathématique, Boulevard du Triomphe CP 210/01, Bruxelles 1050, Belgium, martim.moniz@ulb.ac.be

Co-Author: **Bernard Fortz**, Université Libre de Bruxelles - Graphes et Optimisation Mathématique, Boulevard du Triomphe CP 210/01, Bruxelles 1050, Belgium, bernard.fortz@ulb.ac.be
Luis Neves Gouveia, Professor Catedrático, Universidade de Lisboa, Campo Grande, Lisbon 1749-016, Portugal, legouveia@fc.ul.pt

Abstract: We propose and compare different MIP formulations to the Traffic Engineering problem of finding optimal designs for switched Ethernet networks implementing the IEEE Multiple Spanning Tree Protocol. This problem consists in designing networks with multiple VLANs, such that each one is defined by a spanning tree that meets the required traffic demand. Additionally, all the VLANs must jointly verify the bandwidth capacity of the network. Meanwhile the worst-case link utilization (ratio between link's load and capacity) is minimized. Moreover, we propose a binary search algorithm, that produces near-optimal solutions, by solving a sequence of sub-problems, that can be seen as a capacitated, multiple spanning tree versions of the OCSTP (Hu,74).

ThD13

Updated title and abstract #3

Title: Solving SDP Completely with Interior Point Oracle

Presenting Author: **Bruno Lourenco**, Tokyo Institute of Technology, 2-12-1-W8-41 Ookayama, Meguro-ku, Tokyo, Japan, flourenco.b.aa@m.titech.ac.jp

Co-Author: **Masakazu Muramatsu**, The University of Electro-Communications, 1-5-1 Chofugaoka, Chofu-shi, Tokyo, Japan, muramatu@cs.uec.ac.jp
Takashi Tsuchiya, National Graduate Institute for Policy Studies, 7-22-1 Roppongi, Minato-ku, Tokyo, Japan, tsuchiya@grips.ac.jp

Abstract: We suppose the existence of an oracle able to solve any semidefinite programming (SDP) problem having interior feasible points at both its primal and dual sides. We note that such an oracle might not be able to directly solve general SDPs even after certain regularization schemes are applied. We will show how one can use such an oracle to ‘completely solve’ an arbitrary SDP, including the detection of weak/strong (in)feasibility.

ThD 18

Late Cancellation #3

*****LATE CANCELLATION***A Structured Low Rank Matrix Penalty Method and Applications to Sensor Network**
Tianxiang Liu

ThF30

Late Cancellation #3

*****LATE CANCELLATION***An Experimental Analysis of Karp-Karmarkar One-Dimensional Bin Packing Algorithm**

Otavio Silva

FB05
Late Cancellation #3
***** LATE CANCELLATION *** Evolution Strategies for Stochastic Optimization Problems**
Soualmi Nacer

FB28
Session Cancelled
Title: ***LATE CANCELLATION*Combinatorial Optimization in Networks**
Chair Erick Mopreno-Centeno

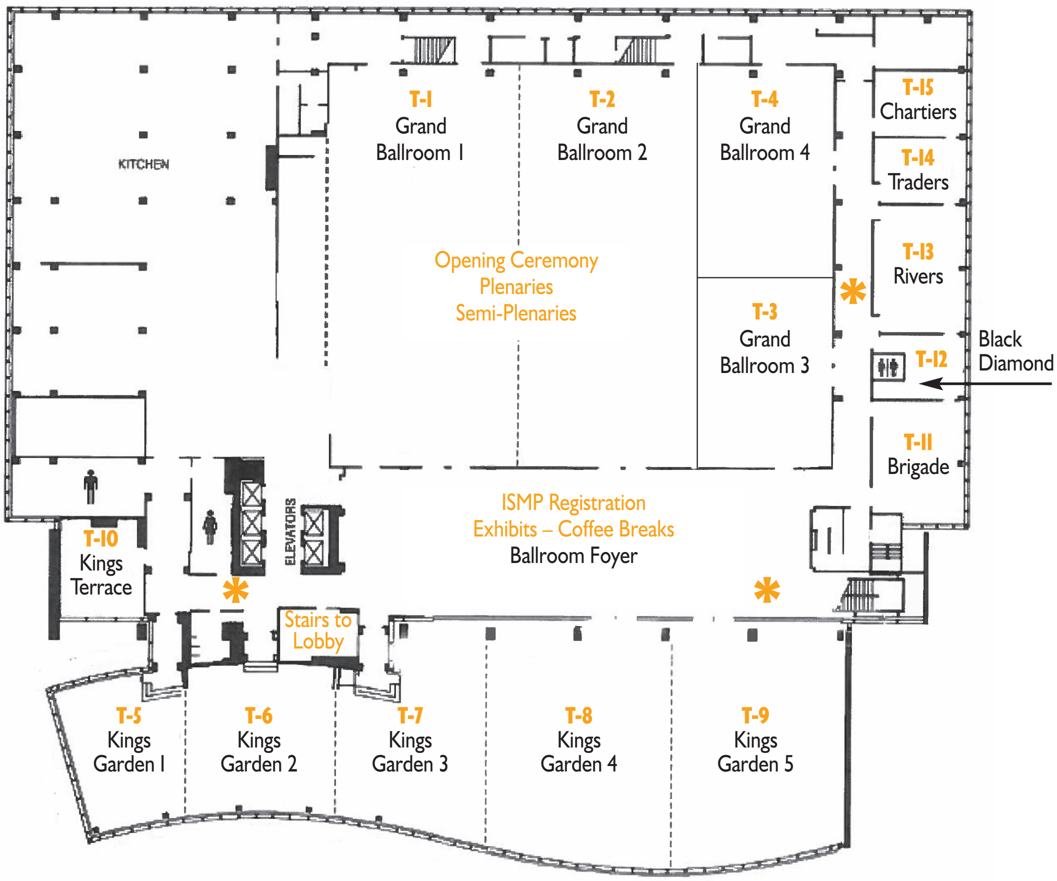
FC01
FC01 and ThC01
Presentation Swap
Computing B-Stationary Points of Nonsmooth DC Programs - moved from ThC01 to FA01
New presenter **Alberth Alvarado**

A Game-Theoretic Approach to Computation Offloading in Mobile Cloud Computing moved from FA01 to ThC01 Francisco Facchinei

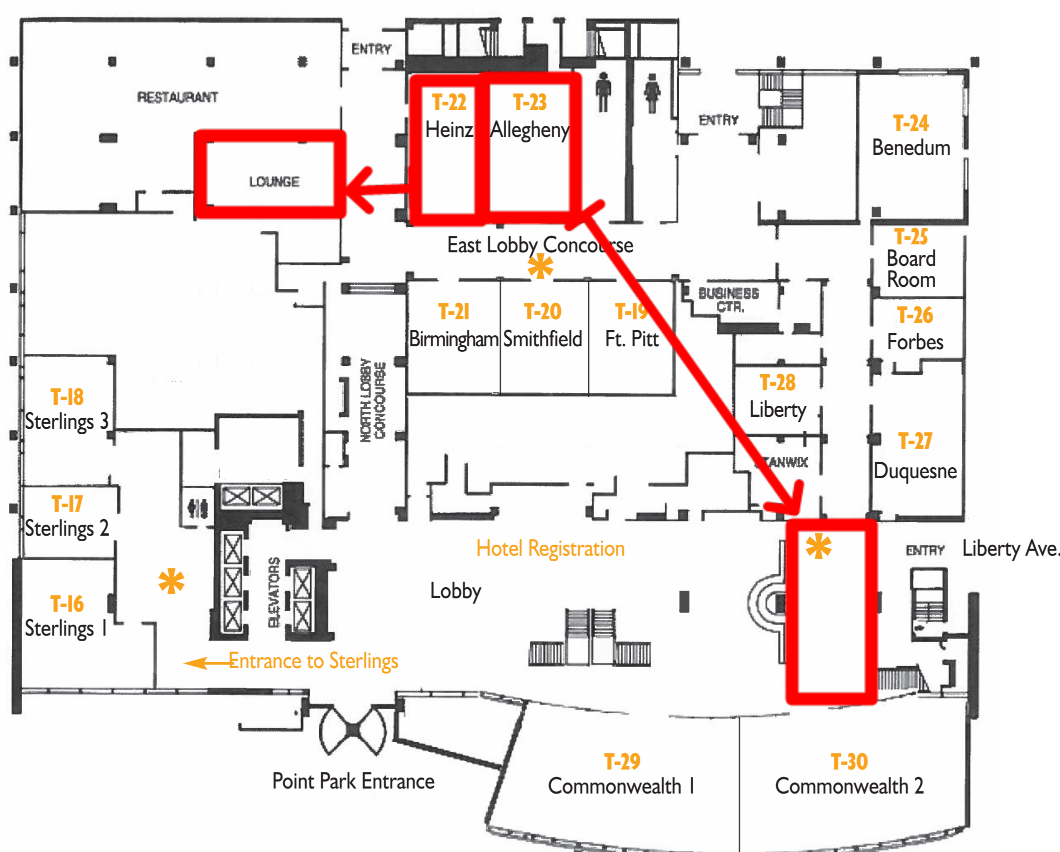
FD02
Late Cancellation
*****Late Cancellation***First-order Methods for Convex Programming and Monotone Operators**
Osman Guler

WYNDHAM GRAND PITTSBURGH

BALLROOM LEVEL
Tracks 1-15



LOBBY LEVEL
Tracks 16-30



✱ **Session Monitor Desks**

How to Navigate the Technical Sessions

There are four primary resources to help you understand and navigate the Technical Sessions:

- This Technical Session listing, which provides the most detailed information. The listing is presented chronologically by day/time, showing each session and the papers/abstracts/authors within each session.
- The Session Chair, Author, and Session indices provide cross-reference assistance (pages 168-184).
- The floor plans on page xxii show you where technical session tracks are located.
- The Master Track Schedule is on pages xvii-xxi.
- This is an overview of the tracks (general topic areas) and when/where they are scheduled.

Quickest Way to Find Your Own Session

Use the Author Index (pages 170-179) — the session code for your presentation(s) will be shown along with the track number. You can also refer to the full session listing for the room location of your session(s).

The Session Codes

TB01

Room number. Room locations are also indicated in the listing for each session.

Time Block. Matches the time blocks shown in the Master Track Schedule.

The day of the week

Time Blocks

Monday
A - 9:00am – 9:50am
B - 10:20am – 11:50am
C - 1:10pm – 2:40pm
D - 2:45pm – 4:15pm
E - 4:35pm – 5:25pm
F - 5:30pm – 7:00pm

Tuesday
A - 9:00am – 9:50am
B - 10:20am – 11:50am
C - 1:10pm – 2:40pm
D - 2:45pm – 4:15pm
E - 4:35pm – 5:25pm

Wednesday
A - 9:00am – 9:50am
B - 10:20am – 11:50am
C - 1:10pm – 2:40pm
D - 2:45pm – 4:15pm
E - 4:35pm – 5:25pm
F - 5:30pm – 6:20pm

Thursday
A - 9:00am – 9:50am
B - 10:20am – 11:50am
C - 1:10pm – 2:40pm
D - 2:45pm – 4:15pm
E - 4:35pm – 5:25pm
F - 5:30pm – 7:00pm

Friday
A - 9:00am – 9:50am
B - 10:20am – 11:50am
C - 1:10pm – 2:40pm
D - 2:45pm – 4:15pm
E - 4:35pm – 5:25pm

Monday, 9:00am - 9:50am

■ MA01

01- Grand 1

Matroid Minors Project

Cluster: Plenary
Invited Session

Chair: Monique Laurent, CWI, Tilburg University, Science Park 123, Amsterdam, 1098 XG, Netherlands, monique@cwi.nl

1 - Matroid Minors Project

Jim Geelen, University of Waterloo, Waterloo, ON, Canada, jfgeelen@uwaterloo.ca

Over the past 15 years I have been working with Bert Gerards and Geoff Whittle on extending the Graph Minors Project, of Paul Seymour and Neil Robertson, to minor-closed classes of representable matroids. This talk is intended to be a gentle overview of our project, covering the main results and some applications in coding theory. No prior exposure to matroid theory is assumed.”

Monday, 10:20am - 11:50am

■ MB01

01- Grand 1

A. W. Tucker Prize

Cluster: Tucker Prize
Invited Session

Chair: Karen Aardal, Delft University of Technology, Mekelweg 4, Delft, Netherlands, K.I.Aardal@tudelft.nl

The A. W. Tucker Prize was established by the Society in 1985, and was first awarded at the Thirteenth Symposium in 1988. Beginning in 2009, it will be awarded at each Symposium for an outstanding doctoral thesis.

Nominations are screened by Tucker Prize Committee. At most three finalists are chosen. The finalists and winner are announced at the opening session of the Symposium, at which time the Prize is awarded. The finalists are invited to give oral presentations of their work at a special session of the Symposium.

■ MB02

02- Grand 2

Complementarity/Variational Inequality I

Cluster: Complementarity/Variational Inequality/Related Problems
Invited Session

Chair: Michael Ferris, Professor, University of Wisconsin, Computer Sciences Department, 1210 West Dayton Street, Madison, WI, 53706, United States of America, ferris@cs.wisc.edu

1 - Gradient Sliding for Saddle Point and Variational Inequality Problems

Guanghui Lan, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, United States of America, glan@ise.ufl.edu

We present a new class of first order methods which can skip the computation of gradients for certaint saddle point and variational inequality problems.

2 - Applications with Complementary Constraints in Chemical Engineering

Lorenz Biegler, Carnegie Mellon University, Pittsburgh, United States of America, biegler@cmu.edu, Alexander Dowling

We explore the application of complementarity constraints to several process design applications in chemical engineering. We formulate chemical equilibrium with possible vanishing phases as a bilevel optimization problem, with Gibbs free energy minimization as the inner problem. The KKT conditions of the inner problem are then reformulated into complementarity constraints and embedded into nonlinear problems for several process design examples. The relationship between non-global solutions of the inner problem and meta-stable phase equilibrium solutions will be discussed.

3 - MOPEC, Contracts, Risk and Stochastics

Michael Ferris, Professor, University of Wisconsin, Computer Sciences Department, 1210 West Dayton Street, Madison, WI, 53706, United States of America, ferris@cs.wisc.edu

We consider extensions of Nash Games to include linking equilibrium constraints and situations where players solve multi-period stochastic programs. We demonstrate when social optima exist, what properties on risk measures and contracts are needed, and how to solve these problems in large scale application domains.

■ MB03

03- Grand 3

Resource Allocation on Networks

Cluster: Combinatorial Optimization

Invited Session

Chair: Tobias Harks, Maastricht University, Tongersetraat 53, Maastricht, Netherlands, t.harks@maastrichtuniversity.nl

1 - Finding Social Optima in Congestion Games with Positive Externalities

Guido Schaefer, CWI, Science Park 123, Amsterdam, 1098XG, Netherlands, G.Schaefer@cwi.nl

We consider the problem of optimizing the social welfare in congestion games where every player i expresses for each resource e and player j a positive externality, i.e., a value for being on e together with player j. We show that this problem is NP-hard even for the special case when the players' utility functions for each resource are affine. We derive a 2-approximation algorithm by rounding an optimal solution of a natural LP formulation of the problem. Our rounding procedure is sophisticated because it needs to take care of the dependencies between the players resulting from the pairwise externalities. We also show that this is essentially best possible by showing that the integrality gap of the LP is close to 2.

2 - Generalized Geometrical Clustering: 1-Median

Andrej Winokurow, Department of Quantitative Economics, Maastricht University, P.O. Box 616, Maastricht, 6200 MD, Netherlands, a.winokurow@maastrichtuniversity.nl, Andre Berger, Alexander Grigoriev

We introduce a generalization of the d-dimensional k-median clustering problem with p-norm, where n data points are grouped around balls of radius R as cluster centers. The linearization or other approximations of the norm do not help to solve the problem. However, for the Manhattan norm and the infinity norm an exact algorithm is presented, which runs in O(n^d). Further, we describe a randomized PTAS for finding a generalized 1-median for small enough R.

3 - Complexity and Approximation of the Continuous Network Design Problem

Max Klimm, TU Berlin, Institut für Mathematik, Sekr. MA 5-2, Strasse des 17. Juni 136, Berlin, Germany, klimm@math.tu-berlin.de, Tobias Harks, Martin Gairing

We revisit the classical (bilevel) continuous network design problem. Given a graph for which the latency of each edge depends on the ratio of the edge flow and the capacity installed, the goal is to find an optimal investment in edge capacities so as to minimize the sum of the routing costs of the induced Wardrop equilibrium and the investment costs for installing the edge's capacities. We show that continuous network design is APX-hard. As for the approximation of the problem, we provide a detailed analysis for a heuristic studied by Marcotte (Math. Program. 1985). Then, we propose a different algorithm and prove that using the better of the two algorithms results in improved approximation guarantees.

■ MB04

04- Grand 4

Geometry, Duality, and Complexity in Convex Optimization I

Cluster: Conic Programming

Invited Session

Chair: Gabor Pataki, University of North Carolina at Chapel Hill, Chapel Hill, NC, Chapel Hill, United States of America, gabor@unc.edu

1 - LP Formulations for Mixed-integer Polynomial Optimization Problems

Daniel Bienstock, Columbia University, 500 W 120th St, New York, NY, 10027, United States of America, dano@ieor.columbia.edu

We present a hierarchy of LP formulations for polynomial optimization problems with guaranteed performance bounds. In the worst case these linear programs have exponential size; however in cases where the intersection graph has bounded tree-width the LPs have linear size for each tolerance level. At the same time the LPs are not relaxations — they compute actual solutions, of smaller size than other recent approaches. As a consequence, we obtain the first polynomial-size LP formulations for the AC-OPF problem on graphs of fixed tree-width, with fixed numerical tolerance level.

2 - Strengthening the Pataki Sandwich Theorem

Vera Roshchina, Lecturer, RMIT University, School of Maths and Geospatial Sciences, Melbourne, Vi, 3310, Australia, vera.roshchina@unimelb.edu.au, Levent Tuncel

The sandwich theorem originally proposed by Gabor Pataki provides (different) necessary and sufficient conditions for a convex cone to be nice (or facially dual complete). We strengthen the necessary condition and discuss examples.

3 - Exact Duality in Semidefinite Programming using Elementary Reformulations

Gabor Pataki, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States of America, gabor@unc.edu, Minghui Liu

We describe an exact, short certificate of infeasibility of semidefinite systems using an elementary approach: we reformulate such systems using only elementary row operations and rotations. When a system is infeasible, the infeasibility of the reformulated system is trivial to verify by inspection. For feasible systems we describe a similar reformulation, which trivially has strong duality with its Lagrange dual for all objective functions. As a corollary, we obtain an algorithm to systematically generate the data of all infeasible semidefinite programs. The second part of this talk (which can be understood independently) is presented by Minghui Liu.

■ MB05

05- Kings Garden 1

Augmented Lagrangian and Related Methods

Cluster: Nonlinear Programming

Invited Session

Chair: Jonathan Eckstein, Professor, Rutgers University, 100 Rockafeller Road, Room 5145, Piscataway, NJ, 08854, United States of America, jeckstei@rci.rutgers.edu

1 - Relative Error Criterion for Multiplier Methods in the Non-Convex Case

Paulo J. S. Silva, Associate Professor, University of Campinas, Rua Sergio Buarque de Holanda 651, Campinas, SP, 13083-859, Brazil, pjssilva@ime.unicamp.br, Alberto Ramos, Jonathan Eckstein

We develop a new criterion for the approximate minimization of augmented Lagrangian subproblems in the non-convex setting based on the relative error criterion of Eckstein and Silva for the convex case. The main advantage of this type of criterion is that the error adapts to the optimization process, becoming more stringent only when convergence is taking place. Our analysis uses Pennanen's duality framework and is based on inexact variants of the proximal point algorithm for hypomonotone operators.

2 - An Asynchronous Distributed Proximal Method for Composite Convex Optimization

Necdet Serhat Aybat, Assistant Professor, PennState University, Industrial Engineering Department, University Park, United States of America, nsa10@psu.edu, Garud Iyengar, Zi Wang

We propose an asynchronous distributed first-order augmented Lagrangian (DFAL) algorithm to minimize sum of composite convex functions, where each term is a private function belonging to one node, and only nodes connected by an edge can directly communicate. This model abstracts various applications in machine-learning. We show that any limit point of iterates is optimal; and for any p>0 and eps>0, an eps-optimal and eps-feasible solution can be computed with probability at least 1-p within O(1/eps log(1/p)) communications in total. We demonstrate the efficiency of DFAL on large scale sparse-group LASSO problems.

3 - Incremental Projective Splitting for Sums of Maximal Monotone Operators

Jonathan Eckstein, Professor, Rutgers University, 100 Rockafeller Road, Room 5145, Piscataway, NJ, 08854, United States of America, jeckstei@rci.rutgers.edu, Patrick Louis Combettes

We develop an approach to computing zeroes of sums of maximal monotone operators in Hilbert space, combining ideas from Eckstein-Svaiter projective splitting with techniques from block-iterative projection methods for convex feasibility problems. The result is a family of decomposition methods in which only a subset of the subproblem systems need to be evaluated between coordination steps, and subproblems and coordination steps may be overlapped asynchronously. The subproblems have a proximal or augmented Lagrangian form. We also discuss applications, including progressive-hedging-like approaches to stochastic programming.

■ MB06

06- Kings Garden 2

Equilibrium Models for Electricity Markets under Uncertainty

Cluster: Optimization in Energy Systems

Invited Session

Chair: Andy Philpott, University of Auckland, Private Bag 92019, Auckland, New Zealand, a.philpott@auckland.ac.nz

1 - SFE Models of Beneficiaries-Pay Transmission Pricing

Anthony Downward, University of Auckland, Level 3, 70 Symonds Street, Grafton, Auckland, 1010, New Zealand, a.downward@auckland.ac.nz, Keith Ruddell, Andy Philpott

We study the effects on supply function equilibrium of a system tax on the observed benefits of generators. Such a tax provides incentives for agents to alter their offers to avoid the tax. We show how this can lead to lower prices in equilibrium. The model is extended to a setting in which the agents are taxed on the benefits accruing to them from a transmission line expansion (to help fund the line).

2 - Electricity Derivative Trading with Private Information on Price Distributions

Eddie Anderson, Professor and Associate Dean (Research), University of Sydney, University of Sydney Business School, Sydney, NS, W 2006, Australia, edward.anderson@sydney.edu.au, Andy Philpott

We examine a framework in which firms trade in a forward market and have some private information on the probability distribution of the final scenarios. Not only do different agents have different private information but they may also have different degrees of confidence in that information. We look for models that reflect the way that forward markets are driven by the hedging behavior of industry participants. We use a supply function model and explore the way in which participants can exploit the bidding behavior of other participants to learn about their private information.

3 - Capacity Equilibrium in Electricity Markets

Andy Philpott, University of Auckland, Private Bag 92019, Auckland, New Zealand, a.philpott@auckland.ac.nz, Golbon Zakeri, Corey Kok

We study the problem of optimal capacity choice by conventional generators in wholesale electricity markets. When demand is increasing this is a capacity expansion problem. When demand is flat and other technologies are growing it can be a optimal capacity reduction problem. We examine incentives in these settings using complementarity models solved by GAMS/PATH.

■ MB07

07- Kings Garden 3

New Developments in Some Optimization Software Packages

Cluster: Implementations and Software

Invited Session

Chair: Erling Andersen, CEO, MOSEK ApS, Fruebjergvej 3, Copenhagen, 2100, Denmark, e.d.andersen@mosek.com

1 - Abstract Glue for Optimization in Julia

Miles Lubin, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-149, Cambridge, MA, 02139, United States of America, mlubin@mit.edu, Madeleine Udell, Tony Kelman, Dominique Orban, Joey Huchette, Iain Dunning

We describe the MathProgBase package in Julia, an abstraction for solver-independent mathematical optimization. Linking multiple modeling packages (JuMP, Convex.jl, AMPL) to a number of open-source and commercial solvers for linear, mixed-integer, conic, and nonlinear optimization, MathProgBase significantly lowers the barrier to developing solvers, meta-solvers, and modeling languages and enables a surprising level of composability without loss of performance by using in-memory interfaces when possible. We present a number of advanced applications.

2 - The CVX Modeling Framework for Disciplined Convex Optimization

Michael Grant, CVX Research, Inc., 1104 Claire Ave., Austin, TX, 78703, United States of America, mcg@cvxr.com

CVX is well-known MATLAB-based framework for constructing and solving convex optimization models, and more recently mixed-integer problems. In this talk we will provide a brief overview of the tool, discuss its latest capabilities, and introduce plans for future development.

3 - Software for Polynomial Optimization in the Julia Language

Joachim Dahl, Software developer, MOSEK ApS, Fruebjergvej 3, Copenhagen, Denmark, joachim.dahl@mosek.com, Martin Skovgaard Andersen, Frank Permenter

We discuss an implementation of the Lasserre hierarchy of semidefinite relaxations for polynomial optimization using the semidefinite optimization capabilities in MOSEK. The conversion from polynomial problems to semidefinite relaxations is implemented in the recent language Julia, which has proven to be remarkable well-suited for such modeling layers. Moreover, we present different applications and discuss how chordal structure can be used to exploit sparsity in the Lasserre hierarchy as well as in sums-of-squares certificates.

■ MB08

08- Kings Garden 4

Linear and Semidefinite Formulations in Combinatorial Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: James Saunderson, Massachusetts Institute of Technology, 77 Massachusetts Ave, 32-D572, Cambridge, MA, 02139, United States of America, jamess@mit.edu

1 - An Axiomatic Duality Framework for the Theta Body and Related Convex Corners

Marcel de Carli Silva, University of São Paulo, Rua do Matao, 1010, São Paulo, Brazil, mksilva@ime.usp.br, Levent Tuncel

The Lovasz theta function is a cornerstone of combinatorial and semidefinite optimization and graph theory. This is partly due to a multitude of equivalent characterizations of the theta function stemming from convex optimization duality. In this work, we extend and unify many such characterizations to a richer class of generalized theta functions, which we show to include the stability number via copositive programming, as well as several related graph invariants via conic optimization.

2 - Exploiting Symmetry in the Turan Semidefinite Program

Annie Raymond, annieraymond@gmail.com, Rekha Thomas, Mohit Singh

We invoke techniques devised by Gatermann and Parrilo (2004) to investigate the role of symmetry in certifying the non-negativity of density inequalities for a-clique-free graphs. We then reevaluate this strategy in light of Razborov's flag algebras.

■ MB09

09- Kings Garden 5

Exact Algorithms for Geometric Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Sàndor P. Fekete, TU Braunschweig, Algorithms Group, Braunschweig, Germany, s.fekete@tu-bs.de

1 - The Wireless Localization Problem: A Successful Combination of IP and Algorithmic Engineering

Cid de Souza, Professor, University of Campinas, Av. Albert Einstein 1251,, Cid. Universitaria, Barao Geraldo, Campinas, SP, 13083-852, Brazil, cid@ic.unicamp.br, Bruno Crepaldi, Pedro de Rezende

Consider the layout of a building given by a 2D-polygon P. Wireless antennas are to be installed at some prespecified potential sites, each broadcasting its own key within a certain angle. In a feasible installation, the set of keys received at any point q in the plane must be enough to decide whether q is inside or outside P. To ascertain this, a Boolean formula must be produced along with the placement of the antennas. The goal is to minimize the number of antennas installed. We formulate the problem as an integer program and show how to reduce the model to manageable sizes. We also highlight several implementation details we used to obtain an efficient algorithm, able to find the optimum for polygons with 1000+ vertices very quickly.

2 - Area- and Boundary-Optimal Polygonalization of Planar Point Sets

Michael Hemmer, TU Braunschweig, Muehlenpfordtstrasse 23, Braunschweig, 38106, Germany, mhsaar@gmail.com, Sandor P. Fekete, Melanie Papenberg, Arne Schmidt, Julian Troegel

Given a set of points in the plane, we consider problems of finding polygonalizations that use all these points as vertices and that are minimal or maximal with respect to covered area or length of the boundary. By distinguishing between polygons with and without holes, this results in eight different problems, one of which is the famous Traveling Salesman Problem. Starting from an initial flexible integer programming (IP) formulation, we develop specific IPs and report preliminary results obtained by our implementation.

3 - Computing MaxMin Edge Length Triangulations

Sandor P. Fekete, TU Braunschweig, Algorithms Group, Braunschweig, Germany, s.fekete@tu-bs.de

We show that finding a MaxMin Edge Length Triangulation for a set of n points in the plane is NP-hard, resolving an open problem dating back to 1991, and discuss exact approaches. A straightforward IP based on pairwise disjointness of the T(n^2) segments has T(n^4) constraints, making this IP prohibitively large, even for relatively small n. We demonstrate how the combination of geometric insights with refined methods of combinatorial optimization can still help to put together an exact method capable of computing optimal MELT solutions for planar point sets up to n = 200. Our key idea is to exploit specific geometric properties in combination with more compact IP formulations, such that we are able to drastically reduce the IPs.

■ MB11

11- Brigade

Flows

Cluster: Combinatorial Optimization

Invited Session

Chair: Renata PoznanskiMSc Student in Operations Research, Tel Aviv University, Israel, Savyon 10, Ramat Gan, 5257523, Israel, renatabo@mail.tau.ac.il

1 - The Budgeted Minimum Cost Flow Problem with Unit Upgrading Cost

Annika Thome, RWTH Aachen University, Kackertstr. 7, Aachen, 52072, Germany, thome@or.rwth-aachen.de, Sarah Kirchner, Christina Büsing

We present a capacitated bi-level minimum cost flow optimization problem. In this problem, we are given a directed graph with several sources and sinks. The arcs are associated with capacities and lower/upper costs. The leader problem is finding a selection of K arcs where the lower costs apply and the follower problem is finding a minimum cost flow that satisfies the demand. In this talk, we prove our problem to be strongly NP-hard even in the single-source single-sink case. However, for special graphs we present polynomial algorithms.

2 - Faster Separation of Robust Single-Commodity Cut-Set Inequalities

Daniel Schmidt, CMU, 317b Posner Hall, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, schmidtd@cmu.edu, Chrysanthos Gounaris

Designing networks that are both reliable and cost-efficient in a large number of scenarios is a difficult task. Here, a challenge is to find a robust integer programming formulation that admits a compact or efficiently separable linear programming relaxation. Two standard robust formulations of the single-commodity network design problem with uncertain demands exist: An arc-flow based formulation with an infinite number of variables and a capacity based formulation with an exponential number of constraints. We explore techniques to approximate the arc-flow based formulation with fewer variables and evaluate the use of meta-heuristics for the NP-hard separation problem that arises from the capacity based formulation.

3 - Optimal Multiperiod Network Flows with Coupling Constraints

Renata Poznanski, MSc Student in Operations Research, Tel Aviv University, Israel, Savyon 10, Ramat Gan, 5257523, Israel, renatabo@mail.tau.ac.il, Refael Hassin

Consider two networks on duplicates of the same directed graph, with given source and sink nodes, but with different edge capacities. Our problem is to compute feasible flows such that the sum of flows is maximized subject to coupling constraints that force identical flows on duplicate copies of the same edge for a subset of edges. We prove that the solution is integral for all possible capacity functions iff the graph is series parallel. We obtain related results for the minimum cost flow problem.

■ MB12 10:30am - 11:00am

12- Black Diamond

MOSEK – Quick Tour of Mosek: Best Practices and its Fusion API

Cluster: Software Presentations

Invited Session

Chair: Andrea Cassioli, Product Manager, MOSEK ApS, Fruebjergvej 3 Symbion Science Park, Box, Copenhagen, Se, 2100, Denmark, andrea.cassioli@mosek.com

1 - MOSEK - Quick Tour of Mosek: Best Practices and its Fusion API

Andrea Cassioli, Product Manager, MOSEK ApS, Fruebjergvej 3 Symbion Science Park, Box, Copenhagen, Se, 2100, Denmark, andrea.cassioli@mosek.com

MOSEK provides high-quality software for conic optimization. The main focus of the software tutorial is two-fold: (1) to guide users through the key features and benefits of our objected-oriented API called FUSION API: speed, expressiveness and simplicity; (2) to discuss some modeling issues and best practices that may be helpful in many cases: scaling, dualization among others. Real-life example inspired by our customer will be used to show how to use MOSEK at its best.

■ MB13

13- Rivers

Optimization Problems with Moments and Polynomials I

Cluster: Conic Programming

Invited Session

Chair: Jiawang Nie, Associate Professor, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA, 92093, United States of America, njw@math.ucsd.edu

Co-Chair: Jean Lasserre, Laboratory for Analysis and Architecture of Systems, lasserre@laas.fr

1 - A Bounded Degree SOS Hierarchy for Polynomial Optimization

Jean Lasserre, Laboratory for Analysis and Architecture of Systems, lasserre@laas.fr, Kim-Chuan Toh

We provide a new hierarchy of semidefinite relaxations for polynomial optimization problems on a compact basic semi-algebraic set. This hierarchy combines some advantages of the standard LP-relaxations associated with Krivine's positivity certificate and some advantages of the standard SOS-hierarchy. In particular (a) for each relaxation the size of the matrix associated with the semidefinite constraint is the same and fixed in advance by the user and (b) finite convergence occurs at the first step of the hierarchy for an important class of convex problems. Finally (c) some important techniques for declaring a polynomial to be zero and to the use of rank-one matrices make an efficient implementation possible.

2 - Convergence Analysis for Lasserre's Hierarchy of Upper Bounds for Polynomial Optimization

Zhao Sun, Tilburg University, P.O. Box 90153, Tilburg, 5000 LE, Netherlands, sunzhao1987@gmail.com, Etienne de Klerk, Monique Laurent

We consider the problem of minimizing a polynomial over a compact set, and analyze a measure-based hierarchy of upper bounds proposed by Lasserre. This hierarchy is obtained by searching for an optimal probability density function which is a sum of squares of polynomials, so that the expectation is minimized. In this talk, we will show its rate of convergence. The main idea is to use the truncated Taylor series of the Gaussian distribution function.

3 - The CP-matrix Approximation Problem

Jinyan Fan, Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai, China, jyfan@sjtu.edu.cn

In this talk, we discuss the CP-matrix approximation problem of projecting a matrix onto the intersection of a set of linear constraints and the cone of CP matrices. We formulate the problem as the linear optimization with the norm cone and the cone of moments. A semidefinite algorithm is presented for the problem. A CP-decomposition of the projection matrix can also be obtained if the problem is feasible.

■ MB14

14- Traders

Pricing and Bargaining with Middlemen

Cluster: Game Theory

Invited Session

Chair: Thanh Nguyen, Krannert School of Management, Purdue University, West Lafayette, United States of America, nguye161@purdue.edu

1 - Optimal Contracts for Intermediaries in Online Advertising

Ozan Candogan, Duke University, Fuqua School of Business, Durham, NC, 27705, United States of America, ozan.candogan@duke.edu, Santiago Balseiro

In online display advertising advertisers often contract with an intermediary to acquire impressions. This paper studies the optimal contract offered by the intermediary in a setting where advertisers' budgets and targeting criteria are private. This problem can be formulated as a multi-dimensional dynamic mechanism design problem. We tackle the problem by employing a novel performance space characterization technique, which provides a convex optimization formulation of the optimal contract design problem. We solve this problem with a duality-based approach, and obtain the optimal contracts. Our results show that an intermediary can profitably provide bidding service to a budget-constrained advertiser, and increases market efficiency.

2 - Population Monotonicity in Newsvendor Games

Zhenyu Hu, University of Illinois, Springfield, IL, United States of America, hu48@illinois.edu, Xin Chen

It is well-known that the core of the newsvendor game is non-empty and one can use duality theory in stochastic programming to construct an allocation belonging to the core, which we refer to as dual-based allocation scheme. In this work, we identify conditions under which the dual-based allocation scheme is a population monotonic allocation scheme (PMAS), which also requires each player's cost decreases as the coalition to which she belongs grows larger. Specifically, we show that the dual-based allocation scheme is a PMAS if and only if the growth of the coalition does not increase the dependence structure between each player and the coalition. Sufficient conditions for population monotonicity are provided for various special cases.

3 - Trade Capacity of A Network

Vijay Subramanian, Associate Professor, University of Michigan, EECS Dept, #4112, 1301 Beal Ave, Ann Arbor, MI, 48109, United States of America, vgsubram@umich.edu, Randall Berry, Thanh Nguyen

We study decentralized markets with the presence of middlemen, modeled by a non-cooperative bargaining game in trading networks. Our goal is to investigate how the network structure of the market and the role of middlemen influence the trade capacity of the market. We show that transaction costs and heterogeneous network structure are the two main channels that give rise to endogenous delay and reduce the trade capacity of the network.

■ MB15

15- Chartiers

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: Tasuku Soma, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan, tasuku_soma@mist.i.u-tokyo.ac.jp

1 - Use of Regularization to Improve the Rate of Convergence in a Model Order Reduction (MOR) Problem

Leobardo Valera, The University of Texas at El Paso, 500 W University Ave, El Paso, TX, 79968, United States of America, lvalera@utep.edu, Martine Ceberio

A way to solve systems of differential equations is by discretizing them, which often leads to a large system of (possibly nonlinear) equations. Even when the systems are linear, direct computations only allow us to solve them in n^3 operations, which may still impose practical limits for large values of n. When looking for a faster solution of such systems of equations in a subspace of the original domain and using Model-Order Reduction, we then have to handle over-determined systems. These can be solved using the Gauss-Newton method, which in non-zero-residual cases is not as efficient as needed. We propose to use techniques inspired by Levenberg and Marquardt to improve the convergence rate of such systems.

2 - Regularization Strategies for Barrier Nonlinear Programming Solvers

Wei Wan, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, weiwan@andrew.cmu.edu, Lorenz Biegler

Barrier methods are widely used nonlinear programming solvers. Nevertheless, these solvers may behave poorly in the presence of degenerate constraints, as they often lead to ill-conditioned KKT matrices applied in the Newton step. To address this problem, we develop structured regularizations of the KKT matrix that lead to well-conditioned systems and preserve matrix inertia. This approach leads to improved performance, as compared with the current version of IPOPT on a large set of test problems.

3 - The Low-Rank Basis Problem for a Matrix Subspace

Tasuku Soma, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan, tasuku_soma@mist.i.u-tokyo.ac.jp, Yuji Nakatsukasa, Andrè Uschmajew

For a given matrix subspace, how can we find a basis that consists of low-rank matrices? This problem can be viewed as a matrix generalization of the sparse basis problem. In this work we provide a greedy algorithm for this problem and analyze its convergence. Our algorithm iteratively finds a matrix of minimum rank in the given subspace that is linearly independent to the matrices already found. We devise a simple procedure for searching such a low-rank matrix by exploiting the soft and hard singular value thresholding. A procedure for avoiding linear dependence is also provided. Our algorithm can be used for representing a matrix with memory requirement far below the classical truncated SVD.

■ MB16

16- Sterlings 1

Provably Strong Formulations

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Ricardo Fukasawa, Associate Professor, University of Waterloo, 200 University Ave West, Waterloo, On, N2L3G1, Canada, rfukasawa@uwaterloo.ca

1 - Theta Body Relaxations are as Strong as Symmetric SDP Relaxations for Matching

Aurko Roy, Georgia Tech University, aurko@gatech.edu

Yannakakis showed that the matching polytope does not have a small symmetric linear extended formulation. It is natural to ask whether the matching polytope can be expressed compactly in a framework such as semidefinite programming (SDP) that is more powerful than linear programming but still allows efficient optimization. We show that the existence of a small symmetric SDP formulation that approximates the matching polytope implies the existence of a small theta body relaxation that achieves the same approximation. Consequently, to lower bound the symmetric SDP rank of the matching polytope for some approximation factor it suffices to lower bound the theta rank.

2 - On Splitting Clutters

Ricardo Fukasawa, Associate Professor, University of Waterloo, 200 University Ave West, Waterloo, On, N2L3G1, Canada, rfukasawa@uwaterloo.ca, Ahmad Abdi, Laura Sanita

For some covering-type problems on graphs, having an integer programming formulation based on directed arcs is preferable to an undirected one, due to the fact that the former is integral, while the latter is not. This motivates us to study what are the intrinsic properties of such operations and how they can be generalized and applied to other contexts. We call such operations splitting over clutters and show how this relates to aspects like integrality, TDI-ness and the packing property.

3 - Lehman's Theorem and the Set Covering Polyhedron

Ahmad Abdi, University of Waterloo, 200 University Ave West, Waterloo, On, N2L3G1, Canada, a3abdi@uwaterloo.ca

In 1965, Alfred Lehman proved that any fractional set covering polyhedron has a highly regular substructure. His result was used by Bertrand Guenin in 1998 to characterize weakly bipartite graphs, thereby settling the graphic case of Paul Seymour's 1977 f-flowing conjecture. In this talk, I will talk about other applications of Lehman's powerful theorem; they include the general case of the f-flowing conjecture, as well as the directed Steiner tree polyhedron. Some parts of the talk are based on joint work with A. Feldmann, B. Guenin, J. Könemann and L. Sanità.

■ MB17

17- Sterlings 2

Exploiting Structure in Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Serge Gratton, Prof. Dr., CERFACS, 42 Avenue Gaspard Coriolis, Toulouse, France, serge.gratton@enseeiht.fr

1 - BFO: A Trainable Derivative-Free for Mixed-Integer Nonlinear Bound-Constrained Optimization

Philippe Toint, Prof. Dr., University of Namur, 61 rue de Bruxelles, Namur, 5000, Belgium, philippe.toint@unamur.be, Margherita Porcelli

A direct-search derivative-free Matlab optimizer for bound-constrained problems is described in the talk, whose remarkable features are its ability to handle a mix of continuous and discrete variables, a versatile interface as well as a novel self-training option. Its performance is compared with that of NOMAD, a state-of-the art package. It is also applicable to multilevel equilibrium- or constrained-type problems. Its easy-to-use interface provides a number of user-oriented features, such as checkpointing and restart, variable scaling and early termination tools.

2 - Action Constrained Quasi-Newton Methods

Robert Gower, PhD Candidate, University of Edinburgh, 2/3 Eden Terrace, Edinburgh, EH10 4SB, United Kingdom, R.M.Gower@sms.ed.ac.uk, Jacek Gondzio

At the heart of Newton based methods is a sequence of symmetric linear systems. Each consecutive system in this sequence is similar to the next, so solving them separately is a waste of computational effort. Here we describe automatic preconditioning techniques for iterative methods for solving such sequences of systems by maintaining an estimate of the inverse system matrix. We update this estimate with quasi-Newton type formulas based on a general action constraint instead of the secant equation. Tests on convex problems reveal that our method is very efficient, converging in wall clock time well before a Newton-CG method without preconditioning. The flexibility of the action constraint allows for other applications.

3 - A Subspace Decomposition Framework for Nonlinear Optimization

Zaikun Zhang, Dr., CERFACS-IRIT Joint Lab, CERFACS, 42 Avenue Gaspard Coriolis, Toulouse, 31057, France, zaikun.zhang@irit.fr, Serge Gratton, Luis Nunes Vicente

We present a parallel subspace decomposition framework for nonlinear optimization, which can be regarded as an extension of the domain decomposition method for PDEs. A feature of the framework is that it incorporates the restricted additive Schwarz methodology into the synchronization phase of the algorithm. We establish the global convergence and worst case iteration complexity of the framework, and illustrate how this framework can be applied to design parallel algorithms for optimization problems with or without derivatives.

■ MB18

18- Sterlings 3

On Cross Scenario Node Constraints for Risk Management in Stochastic Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Laureano F. Escudero, Profesor (retired), Universidad Rey Juan Carlos, Tulipan st, Mostoles (Madrid), SP, 28933, Spain, laureano.escudero@urjc.es

1 - Cluster Lagrangean Decomposition for Large-Scale Multi-Stage Mixed 0-1 Stochastic Problems

Maria Araceli Garin, Profesor, Universidad del Pais Vasco, Lehendakari Aguirre 83, Bilbao, 48015, Spain, mariaaraceli.garin@ehu.es, Laureano F. Escudero, Celeste Pizarro, Aitziber Unzueta

We present a methodology for obtaining strong bounds on risk neutral and risk averse (with first- and second-order time stochastic dominance constraints) multistage stochastic problems. The whole problem is represented by a mixture of the splitting and the compact representation. The dualization of the nonanticipativity constraints of some variables in the risk neutral version and the additional dualization of the cross scenario group constraints in the risk averse model, allows to decompose each of them into a set of independent cluster submodels. Four schemes for the Lagrangean multipliers updating are compared and computational results are presented.

2 - On Parallel BFC Based Matheuristics for Solving SMIP under Time Stochastic Dominance Constraints

Unai Aldasoro, Post-doc, Universidad del Pais Vasco, Fac. de Ciencias y Tecnologia, c/o Prof. Gloria Perez, Leioa, Vi, 48940, Spain, unai.aldasoro@ehu.es, Laureano F. Escudero, Maria Araceli Garin, Maria Merino, Gloria Perez

The Time Stochastic Dominance (TSD) risk averse strategy is considered for large stochastic multistage mixed 0-1 problems. Three parallel computing matheuristics as spin-offs of the TSD Branch-and-Fix Coordination methodology are presented . A computational experience is reported for assessing the quality of the heuristic solution by considering the TSD and Risk Neutral strategies. Parallel computing provides a perspective for solving large-scale instances by using a simultaneous coordinated branching scheme on the 0-1 variables and an iterative incumbent solution exchange to obtain tighter bounds of the original problem.

3 - A Time Stochastic Dominance Functional for Risk Management in Multistage Stochastic Optimization

Laureano F. Escudero, Profesor (retired), Universidad Rey Juan Carlos, Tulipan st, Mostoles (Madrid), SP, 28933, Spain, laureano.escudero@urjc.es, Maria Araceli Garin, Maria Merino, Gloria Perez

We extend to the multistage case two recent risk averse measures for two-stage stochastic programs based on first- and second-order stochastic dominance constraints induced by mixed-integer-linear recourse. An extension of our Branch-and-Fix Coordination algorithm, so named BFC-TSD, is presented where a special treatment is given to the cross node constraints for modeler-chosen stages. A broad computational experience is presented by comparing the risk neutral approach and the risk averse functional. The performance of the new version of the BFC algorithm versus the plain use of a state-of-the-art MIP solver is also reported.

■ MB19

19- Ft. Pitt

Challenges in PDE-Constrained Optimization

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Michael Ulbrich,, Professor, TU Muenchen, Dept. of Mathematics, Boltzmannstr. 3, Garching, 85747, Germany, mulbrich@ma.tum.de

1 - An Optimal Control Problem from Implant Shape Design

Anton Schiela, Professor, Universitaat Bayreuth, Universitaat Bayreuth, Bayreuth, 95440, Germany, anton.schiela@uni-bayreuth.de, Lars Lubkoll, Martin Weiser

We discuss a design problem for a facial bone implant that can be described as an optimal control problem. The main difficulty is the modelling of the facial soft tissue as a nonlinear elastic material. The resulting optimization problem in function space is tackled by an affine covariant composite step method. In the talk we develop the main algorithmic ideas of this method and show numerical examples from applications.

2 - Robust Optimization of a Permanent Magnet Synchronous Motor Geometry

Oliver Lass, TU Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, lass@mathematik.tu-darmstadt.de, Stefan Ulbrich

The goal is to optimize the volume and position of permanent magnet material in the rotor of a synchronous machine while maintaining a given performance level. Due to manufacturing, there are uncertainties in material and production precision. A robust optimization problem is formulated that accounts for a selected set of uncertainties. We present approximation techniques of first and second order for the robust counterpart of general uncertain nonlinear programs governed by partial differential equations. Numerical results are presented for validation.

3 - Optimization of Nonlinear Hyperbolic Conservation Laws with Switching Controls

Stefan Ulbrich, Professor, TU Darmstadt, Dolivostr. 15, Darmstadt, Germany, ulbrich@mathematik.tu-darmstadt.de, Sebastian Pfaff

We consider optimization problems for nonlinear conservation laws in 1D. The time-dependent control acts at the boundary and switches between different C^1-functions or acts as an on/off-switch in the interior. This allows to model switched controls in networks of conservation laws describing, e.g., traffic- or fluid flow with switching (traffic lights, valves, etc.). Although the solution develops discontinuities, we show for scalar problems that typical objective functions are differentiable w.r.t. the switching times and derive an adjoint-based gradient formula. Hence, derivative based optimization methods can be applied efficiently to optimize the switching times.

■ MB20

20- Smithfield

Algorithms for Convex Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Javier Pena,, Professor of Operations Research, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, jfp@andrew.cmu.edu

1 - Variants of the von Neumann Algorithm

Negar Soheili, Assistant Professor, University of Illinois at Chicago, 601 S Morgan Street, University Hall 2416, Chicago, IL, 60607, United States of America, nazad@uic.edu, Daniel Rodriguez, Javier Pena

The von Neumann algorithm is a simple greedy algorithm to determine whether the origin belongs to a polytope generated by a finite set of points. The algorithm's rate of convergence depends on the radius of the largest ball around the origin contained in the polytope. We propose some variants of the von Neumann algorithm that retain the algorithm's simplicity while achieving faster convergence rate.

2 - On the Frank-Wolfe Algorithm with Away Steps

Daniel Rodriguez, PhD Candidate, Mathematics, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, drod@cmu.edu, Javier Pena, Negar Soheili

The Frank-Wolfe Algorithm for minimizing a convex function over a polytope has attractive properties due to its simplicity and low computational cost. We show that for some convex functions a variant of the Frank-Wolfe Algorithm, which performs "away steps" at certain iterations, generates a sequence of points whose objective values converge linearly to the minimum. We provide some insightful connections between the algorithm's rate of convergence and the geometry of the problem.

3 - Iterative Shrinkage Tresholding Algorithm with Second Order Information

Hiva Ghanbari, PhD Student, Lehigh University, Harold S. Mohler Laboratory,, 200 W. Packer Ave., Bethlehem, PA, 18015, United States of America, hig213@lehigh.edu

We focus on the effect of using second order information through the Limited memory BFGS method, on the accelerated version of Iterative Shrinkage Tresholding Algorithm. Specifically, we apply this modified method on the composite optimization problems as the sum of a smooth convex function and a non-smooth convex function using proximal-gradient method. We present the analysis reflecting the use of second order information and supporting numerical result.

■ MB21

21-Birmingham

Integer Flows, Distance Queries, and Disjoint Paths in Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Álvaro Junio Pereira Franco, Federal University of Santa Catarina, Rod. Gov. Jorge Lacerda, 3201, Ararànguà, SC, 88906-072, Brazil, alvaro.junio@ufsc.br

1 - Nowhere-zero Flows: The 'Minas Gerais' of Graph Theory

Cándida Nunes da Silva, DComp - CCGT - Universidade Federal de São Carlos, Rodovia Joào Leme dos Santos, km 110, Sorocaba, SP, 18052-780, Brazil, candida@ufscar.br

In 1954, William T. Tutte introduced the concept of (nowhere-zero) k-flows as a means to generalize the concept of a face k-colouring to non-planar graphs. Tutte also proposed three celebrated conjectures regarding k-flows, which remain open. There is a surprisingly high concentration of simple and elegant theorems in this subject, many of which should probably be in the "Book of God" described by Paul Erdos. Such fact inspired Daniel H. Younger to call this topic the 'Minas Gerais' of Graph Theory; an allusion to a Brazilian region that had an amazingly high concentration of gold and diamond and was intensely exploited by the Portuguese in the past. A selection of precious theorems regarding k-flows will be presented.

2 - Robust Exact Distance Queries on Massive Networks

Renato Werneck, San Francisco, CA, United States of America, rwerneck@acm.org, Thomas Pajor, Daniel Delling, Andrew Goldberg

We present a versatile and scalable algorithm for computing exact distances on real-world networks with tens of millions of arcs in real time. Unlike existing approaches, preprocessing and queries are practical on a wide variety of inputs, such as social, communication, sensor, and road networks. We achieve this by providing a unified approach based on the concept of 2-hop labels, improving upon existing methods. In particular, we introduce a fast sampling-based algorithm to order vertices by importance, as well as effective compression techniques. This work was done at Microsoft Research Silicon Valley.

3 - From a Min-Max Relation to an Algorithm to Construct the Dominator Tree of a Reducible Flowgraph

Álvaro Junio Pereira Franco, Federal University of Santa Catarina, Rod. Gov. Jorge Lacerda, 3201, Ararangua, SC, 88906-072, Brazil, alvaro.junio@ufsc.br, Carlos Eduardo Ferreira

We observed the following min-max relation in flowgraphs: given a flowgraph G, the minimum size of a dominator cover of G is equal to the maximum size of a junction partition of G. From this min-max relation we derived an output-sensitive algorithm to construct the dominator tree of a given reducible flowgraph.

■ MB22

22- Heinz

Algorithms for Non-Convex Problems and Applications

Cluster: Global Optimization

Invited Session

Chair: Miguel Anjos,, Professor and Canada Research Chair, Polytechnique Montreal, C.P. 6079, Succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, miguel-f.anjos@polymtl.ca

1 - A Projected-Gradient Newton Type Algorithm for Solving Feasibility Problems with Complementarity

Tiara Martini, Department of Applied Mathematics, State University of Campinas, Rua Sérgio Buarque de Holanda, 651, Campinas, SP, 13083-859, Brazil, tiaramartini@gmail.com, Joaquim Judice, Roberto Andreani, José Mario Martínez

A Projected-Gradient Underdetermined Newton type (PGUN) algorithm is introduced for finding a solution of Rectangular Nonlinear Complementarity Problem (RNCP) corresponding to a feasible solution of a Mathematical Programming Problem with Complementarity Constraints (MPCC). The method employs a combination of Newton and Projected-Gradient directions and a line-search procedure that guarantees global convergence to a solution of RNCP or at least a stationary point of the merit function associated. PGUN can also be applied to the computation of a feasible solution of MPCC with a target objective function value. Computational experience is reported illustrating the efficiency of the algorithm to find feasible solutions of MPCC in practice.

2 - Global Solution of General Quadratic Programs

Amélie Lambert, CEDRIC-Cnam, 292 rue Saint Martin, Paris, 75003, France, amelie.lambert@cnam.fr, Sourour Elloumi

Let P be MIQCP that consists of minimizing a quadratic function subject to quadratic constraints. The variables can be integer or continuous. Our approach is first to consider P' that is equivalent to P. Problem P' has additional variables that are meant to be equal to the product of pairs of initial variables. When this equality is relaxed, the obtained problem from P' is quadratic and convex. Consequently, problem P' can be solved by a B&B, based on this relaxation. Moreover, our equivalent problem P' is built from the solution of a semidefinite programming relaxation of (P) and captures its strength. Computational experiences show that our general method is competitive with standard solvers, on many instances.

3 - An Improved Two-Stage Optimization-Based Framework for Unequal-Areas Facility Layout

Miguel Anjos, Professor and Canada Research Chair, Polytechnique Montreal, C.P. 6079, succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, miguel-f.anjos@polymtl.ca, Manuel V.C. Vieira

The facility layout problem seeks the optimal arrangement of non-overlapping departments with unequal areas within a facility. We present an improved framework combining two mathematical optimization models. The first model is a nonlinear approximation that establishes the relative position of the departments, and the second model is an exact convex optimization formulation of the problem that determines the final layout. Aspect ratio constraints are taken into account by both models. Our preliminary results show that the proposed framework is computationally efficient and consistently produces competitive, and often improved, layouts for instances from the literature as well as for new large-scale instances with up to 100 departments.

■ MB23

23- Allegheny

Robust and Adaptive Optimization

Cluster: Robust Optimization

Invited Session

Chair: Vineet Goyal, Columbia University, 500W 120th St, New York, NY, United States of America, vgoyal@ieor.columbia.edu

1 - Optimal and Near Optimal Data-Driven Ambiguity Sets

Vishal Gupta, Assistant Professor, USC Marshall School of Business, 3670 Trousdale Parkway, Bridge Hall 401 G, Los Angeles, CA, 90089-0809, United States of America, guptavis@marshall.usc.edu

We present a novel technique for constructing ambiguity sets for data-driven distributionally robust optimization. Like existing proposals, our sets are tractable, asymptotically consistent, and enjoy a finite sample performance guarantee. By combining Bayesian techniques and convex analysis, we prove that these new sets are the smallest possible ambiguity sets satisfying these properties. In this sense, they are optimal. For some special cases, we theoretically characterize the relative size of our new set to existing proposals, demonstrating a full order of magnitude improvement. Numerical experiments confirm the effectiveness of these sets over existing proposals in applications.

2 - From Predictive to Prescriptive Analytics

Nathan Kallus, Massachusetts Institute of Technology, 77 Massachusetts Ave E40-149, Cambridge, MA, 02139, United States of America, kallus@mit.edu, Dimitris Bertsimas

Combining ideas from machine learning and operations research, we develop a framework and solutions for data-driven optimization given historical data and, in a departure from other work, an observation of auxiliary quantities associated with the key uncertain variable. We show that our method is generally applicable to many problems, tractable, and asymptotically optimal even if data is not iid. To demonstrate the power of our approach in a real-world setting, we study an inventory management problem faced by the distribution arm of an international media conglomerate. We leverage both internal company data and public online data harvested from IMDb, Rotten Tomatoes, and Google to prescribe operational decisions that outperform benchmarks.

3 - On the Adaptivity Gap in Dynamic Robust Optimization

Vineet Goyal, Columbia University, 500W 120th St, New York, NY, United States of America, vgoyal@ieor.columbia.edu, Dimitris Bertsimas, Brian Lu

In this talk, I will present recent progress on the performance of static robust solutions for dynamic robust linear programs under constraint-coefficient uncertainty. We show that static solution is near-optimal for dynamic robust linear optimization problems under under fairly general conditions. In particular, we relate the performance of the static solutions to a measure of non-convexity of a transformation of the uncertainty set. We also consider the class of column-wise and constraint-wise uncertainty sets that arise naturally in many applications and provide a stronger bound on the adaptivity gap.

■ MB24

24- Benedum

Semidefinite and Copositive Approaches for Robustness

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Sam Burer, Professor, University of Iowa, S346 Pappajohn Business Building, Iowa City, IA, 52246, United States of America, samuel-burer@uiowa.edu

1 - Robust Sensitivity Analysis in the Optimal Value of Linear Programming

Guanglin Xu, PhD Student, Department of Management Sciences, The University of Iowa, S221 Pappajohn Business Building, Iowa City, IA, 52246, United States of America, guanglin-xu@uiowa.edu, Sam Burer

We study sensitivity analysis of the optimal value of linear programming under general perturbations of the objective coefficients and right-hand sides. This leads to non-convex quadratic programs (QPs), which are difficult to solve in general. We then propose copositive relaxations of these QPs that, while exact in some cases, are still computationally intractable. Finally, we derive corresponding tractable relaxations and present preliminary computational results to demonstrate their quality.

2 - Sparse but Efficient Operation: A Conic Programming Approach

Chung Piaw Teo, Prof, National University of Singapore, 1 Business Link, Singapore, Singapore, bizteocp@nus.edu.sg, Yini Gao, Zhenzhen Yan

Motivated by a workforce deployment problem in Changi International Airport (Singapore), we develop a conic programming approach to design efficient allocation/deployment solution that exploits a sparse substructure to respond to changes and deviations in the operational environment. In the case of process flexibility problem, our method can recover the k-chain structures that are known to be extremely efficient for this type of problem.

3 - Distributionally Robust Project Crashing with Moments

Karthik Natarajan, Associate Professor, Singapore University of Technology and Design, 8 Somapah Rd, Singapore, 487372, Singapore, natarajan_karthik@sutd.edu.sg, Selin Damla Ahipasãoglu, Dongjian Shi

Project crashing is a method for shortening the project duration by reducing the time of one or more activities in a project network to less than its normal activity time with additional cost. In reality activity durations are often uncertain. We propose a distributionally robust project crashing problem to minimize the worst-case expected project duration with a given budget for cost where the distributions of the activity durations are only partly specified with moments. We develop a formulation for the distributionally robust project crashing problem as a saddle point problem. Instead of solving a semidefinite program or a completely positive program, we develop a simpler algorithm to optimally crash the projects.

■ MB25

25- Board Room

Constraint-Based Scheduling I

Cluster: Constraint Programming

Invited Session

Chair: Philippe Laborie, IBM, 9, rue de Verdun, Gentilly, 94253, France, phi.laborie@free.fr

1 - Constraint-Based Search Methods for Dynamic Pickup and Delivery Problems

Stephen Smith, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, sfs@cs.cmu.edu, Zachary Rubinstein, Laura Barbulescu

We focus on constraint-based search techniques for maintaining an optimized pickup and delivery schedule as new requests are received and other disruptive events occur over time. In this context, the current schedule provides a reference point for the set of executing agents and there is pragmatic value to maintaining stability when possible. We describe a controlled, iterative search framework for revising the current schedule in response to such dynamic events. The efficacy of the approach is demonstrated on both benchmark problems and real problem data from a paratransit scheduling application.

2 - Constraint-Based Scheduling by Learning

Andreas Schutt, Researcher, NICTA and University of Melbourne, 115 Batman Street, Melbourne, Australia, Andreas.Schutt@nicta.com.au, Thibaut Feydy, Peter Stuckey

Constraint-based scheduling is one of the success stories in constraint programming (CP). Recent advanced CP solvers additionally include sophisticated conflict learning technologies. Experiments on different kind of scheduling problems, such as resource-constrained project scheduling with generalised precedence relations and flexible jobshop scheduling show that CP solvers incorporating conflict learning technologies outperform traditional CP solvers and state-of-the-art methods on some hard combinatorial problems. This talk gives an overview of such a technology developed at NICTA, Australia, and presents recent results on a few different common scheduling problems.

3 - Failure-directed Search for Constraint-based Scheduling

Petr Vilim, IBM Czech Republic, V Parku 2294/4, Prague, Czech Republic, petr_vilim@cz.ibm.com

Failure-directed search is a new constraint programming search algorithm that performs very well for number of scheduling problems (job shop, RCPSP, ..). It focuses on a systematic exploration of the search space, first eliminating assignments that are most likely to fail. Automatic search in IBM CP Optimizer (part of CPLEX Optimization Studio) is using failure-directed search as a “plan B” strategy once a less systematic Large Neighborhood Search is not improving any more.

■ MB26

26- Forbes Room

Optimal Portfolio Modeling

Cluster: Finance and Economics

Invited Session

Chair: John Birge, University of Chicago, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States of America, jbirge@chicagobooth.edu

1 - Using Simulation to Assess the Long-Term Effects of Bank Policies and Regulation

Pedro Judice, ISCTE, Rua da Madalena,113, 2 esq, Lisbon, 1100-319, Portugal, pedro_judice@yahoo.com, John Birge

Using long-term commercial bank scenario generation, we develop new balance sheet equations using the concept of target leverage and funding ratios, and define new risk and return metrics. We use the framework of these equations to quantify the benefits of low leverage, stable funding, low operating costs and activity in high interest rate environments. Our results show that the current Basel III regulation does not significantly reduce bank failure, as it gives an incentive to wholesale funding with more than a year’s maturity and the non-risk based leverage ratio limit is low. A better option for banks is to keep core deposits high and have the non-risk based leverage ratio much higher than the 3% limit imposed by the Basel Committee.

2 - Performance Analysis with Respect to an Unobserved Benchmark

Luis Chavez-Bedoya, Universidad Esan, Alonso de Molina 1652, Surco, Lima, Lima 33, Peru, lchavezbedoya@esan.edu.pe

In the framework of active portfolio management, we proposed a methodology to analyze the relative performance of a set of active managers when the benchmark is either not observed or it cannot be precisely determined by the agent performing the analysis. The methodology assesses performance with respect to an equally-weighted portfolio based on the funds under evaluation. Moreover, the fund’s betas relative to the aforementioned portfolio carry important information about relative performance in terms of information ratio. Finally, the methodology is suitable to assess performance of regulated defined-contribution pension funds.

3 - Linear Programming Approach to American Option Pricing

Zhen Liu, Options Clearing Corporation, 1547 7 Pines Road, D2, Schaumburg, IL, 60193, United States of America, zhenliu@alum.northwestern.edu

We solve the variational inequality (VI) from American option pricing problem by linear programming (LP) approach. We approximate its solution by a combination of basis functions. The objective is to minimize the absolute error of the solution and the max operator in VI is converted into linear constraints of LP. We discuss its convergence, and compare our results with Longstaff-Schwartz least-square approach and numerical partial differential equation (PDE) approach.

■ MB27

27- Duquesne Room

Sparse Optimization and Compressed Sensing

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Hongcheng Liu, Student, The Pennsylvania State University, Dept. of Industrial and Manufacturing En, Pennsylvania State University, State College, PA, 16802, United States of America, hql5143@psu.edu

1 - Compressed Sensing of Data with Known Distribution

Mateo Dìaz Dìaz, Universidad de los Andes, Cra 1 N∫ 18A- 12 Dep. de Matematicas, Bogota, Colombia, m.diaz565@uniandes.edu.co, Mauricio Junca, Felipe Rincòn, Mauricio Velasco

Compressive sensing is a technique with many important applications. For all these applications the most important parameter is the number of measurements required for perfect recovery. In this work we are able to drastically reduce the number of required measurements by incorporating information about the distribution of the data we wish to recover. Our algorithm works by minimizing an appropriately weighted l1 norm and our main contribution is the determination of good weights.

2 - Models and Architectures for Video Compressive Sensing

Aswin Sankaranarayanan, Assistant Professor, Carnegie Mellon University, ECE Dept, 5000 Forbes ave, Pittsburgh, PA, 15213, United States of America, saswin@andrew.cmu.edu

In this talk, I will outline an emerging method for sensing videos that (a) exploits redundancies in real-world videos, to (b) sense with far-fewer measurements as compared to a traditional sensor. I will present how state of the art models in video compression, which rely on motion-flow, can be used for compressive sensing. Specifically, I will discuss the design of scalable video compressive systems where the co-design of optics, in terms of novel imaging architectures, and algorithms, in terms of novel measurement matrices and video models, enable sensing at high spatial and temporal resolutions.

3 - Folded Concave Penalized Sparse Linear Regression: Complexity, Sparsity and Statistical Guarantee

Hongcheng Liu, Student, The Pennsylvania State University, Dept. of Industrial and Manufacturing En, Pennsylvania State University, State College, PA, 16802, United States of America, hql5143@psu.edu, Tao Yao, Runze Li, Yinyu Ye

This paper concerns the folded concave penalized sparse linear regression (FCPSLR) problem, which is an alternative sparse recovery method than the Lasso. A preferable property of FCPSLR is its exact recovery of the oracle solution per Zhang and Zhang (2012) when it is minimized globally. In this present paper, we first show that solving FCPSLR globally is NP-complete. Then, we provide a spectrum of conditions for any local solution to be a sparse estimator. More importantly, we show that for the regression problems with random design matrices, the recovery of the oracle solution is an immediate result of FCPSLR’s innate properties at a local solution satisfying a second order necessary condition, independent of the solution algorithms.

■ MB28

28- Liberty Room

Advances in Integer Programming I

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - A Heuristic Approach for Sequential Dependent Set-Up Timed Multi-Stage Hybrid Flow Shop Scheduling Problem

Müjgan Sagir, Professor, ESOGU, Engineering Faculty, Meselik, Eskisehir, 26480, Turkey, mujgan.sagir@gmail.com, Hacer Defne Okul

The scheduling of flow shops with multiple parallel machines per stage, referred to as the hybrid flow shop (HFS). This paper proposes a systematic approach to solve k-stage HFS scheduling problem for the objective of minimizing the makespan. The problem is to determine the allocation of jobs to the paralel machines as well as the sequence of the jobs assigned to each machine. A real life case is provided to compare current and proposed schedules.

2 - A Matheuristic for the Curriculum-Based Course Timetabling

Michael Lindahl, Technical University of Denmark, Produktionstorvet, Bygning 426, Lyngby, 2800, Denmark, miclin@dtu.dk, Matias Sörensen, Thomas Stidsen

The Curriculum-based University timetabling is a complex scheduling problem. In practice short running times are important and standard MIP solvers have difficulties finding high quality solution within these short running times. We propose a matheuristic that uses a decomposed two stage model of the problem. The algorithm creates smaller neighbourhoods by fixing and releasing connected variable and are this way able to obtain high quality solutions within short running times.

3 - A New Model to Advance Accuracy and Solution Speed in Road Design

Vahid Beiranvand, University of British Columbia, ASC 306, 3333 University Way, Kelowna, V1V 1V7, Canada, vahid.beiranvand@ubc.ca, Warren Hare, Shahadat Hossain, Yves Lucet

The vertical alignment optimization problem for road design aims to generate a vertical alignment of a new road with a minimum cost, while satisfying safety and design constraints. In this paper, we present a new model called multi-haul quasi network flow for vertical alignment optimization that improves the accuracy and reliability of a previous mixed integer linear programming model. We evaluate the performance of the new model compared to two current state-of-the-art models in the field. Numerical results will be discussed. Work on this project has been done in collaboration with our industry partner, Softree Technical Systems Inc.

■ MB29

29- Commonwealth 1

Coordinate Descent Methods for Sparse Optimization Problems I

Cluster: Nonsmooth Optimization

Invited Session

Chair: Xin Liu, Associate Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, ICMSEC510, 55, Zhong Guan Cun East Road, Beijing, China, liuxin@lsec.cc.ac.cn

1 - A Greedy Coordinate Descent Algorithm for Cardinality Constrained Convex Smooth Optimization

Ji Liu, University of Rochester, University of Rochester, Rochester, NY, 14627, United States of America, ji.liu.uwisc@gmail.com

We propose a forward-backward greedy coordinate descent algorithm for solving cardinality constrained convex smooth optimization, which is NP hard in general. We provide an upper bound of the difference between the true solution and the solution given by the proposed greedy method. This upper bound implies a sufficient condition to exactly solve the NP hard optimization. This sufficient condition is weaker (better) than the conditions required by many convex relaxation methods, for example, LASSO.

2 - First-Order Algorithms for Block Optimization: An Iteration Complexity Analysis

Shuzhong Zhang, Professor, University of Minnesota, Department of Industrial and Systems Eng, Minneapolis, MN, 55455, United States of America, zhangs@umn.edu

In this talk we shall discuss block optimization models arising from tensor projection problems and machine learning. Such models include non-separable but convex optimization and separable but non-convex optimization. We present a suite of first-order solution algorithms for solving such problems, which can be broadly described as variants of the proximal gradient and/or ADMM type methods. An iteration complexity analysis of the proposed algorithms for the afore-mentioned convex or non-convex optimization models will be presented.

3 - Magnetic Susceptibility Inversion with Full Tensor Gradient Data using the Sparse Regularization

Yanfei Wang, Institute of Geology and Geophysics, Chinese Academy of Sciences, No.19 Beitucheng Xilu, Chaoyang District, Beijing, China, yfwang@mail.iggcas.ac.cn

Retrieval of magnetization parameters using magnetic tensor gradient measurements receives attention in recent years. Little regularizing inversion results using gradient tensor modeling so far has been reported in the literature. Traditional magnetic inversion is based on the total magnetic intensity (TMI) data and solving the corresponding mathematical physical model. In this paper, we study invert the magnetic susceptibility using the full tensor gradient magnetic data. A sparse Tikhonov regularization model is established. In solving the minimization model, an alternating directions method is addressed. Numerical experiments are performed to show feasibility of our algorithm.

■ MB30

30- Commonwealth 2

Approximation and Online Algorithms I

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Lisa Zhang, Bell Labs Alcatel-Lucent, 600 Mountain Ave, 2A-442, Murray Hill, NJ, 07974, United States of America, ylz@research.bell-labs.com

1 - New Approximation Schemes for Unsplittable Flow on a Path

Tobias Mömke, Saarland University, Postfach 42 (Blaser), 66123 Saarbrücken, Saarbrücken, Germany, moemke@cs.uni-saarland.de, Jatin Batra, Amit Kumar, Andreas Wiese, Naveen Garg

We study the unsplittable flow on a path problem. We make progress towards finding a PTAS for this important problem. When the task densities - defined as the ratio of a task's profit and demand - lie in a constant range, we obtain a PTAS. We also improve the QPTAS of Bansal et al. by removing the assumption that the demands need to lie in a quasi-polynomial range. Our third result is a PTAS for the case where we are allowed to shorten the paths of the tasks by at most an epsilon-fraction. This is particularly motivated by bandwidth allocation and scheduling applications of our problem if we are allowed to slightly increase the speed of the underlying transmission link/machine.

2 - Analysis of K-Anonymity Algorithms for Streaming Location Data

Lisa Zhang, Bell Labs Alcatel-Lucent, 600 Mountain Ave, 2A-442, Murray Hill, NJ, 07974, United States of America, ylz@research.bell-labs.com, Matthew Andrews, Gordon Wilfong

We analyze algorithms to achieve k-anonymity for streaming location data, where anonymity is achieved by recording coarse common regions each of which contains at least k points. Our goal is to minimize the recorded region size so that the anonymized location is as accurate as possible. Under the adversarial model, any online algorithm can have an arbitrarily bad competitive ratio. Assuming a uniform distribution of locations, we show a simple algorithm that achieves k-anonymity and has almost matching upper and lower bounds on region size. Finally, for nonuniform distributions, we discuss heuristics that partition the space to match the given distribution before applying the algorithm for uniform distributions.

Monday, 1:10pm - 2:40pm

■ MC01

01- Grand 1

First Order Primal/Dual Methods

Cluster: Nonsmooth Optimization

Invited Session

Chair: Martin Takac, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, United States of America, martin.taki@gmail.com

Co-Chair: Martin Jaggi, Universitaetsstr 6, Zürich, 8092, Switzerland, jaggi@inf.ethz.ch

1 - Convex Interpolation and Performance Estimation of First-Order Methods

Francois Glineur, Université Catholique de Louvain, CORE, Voie du Roman Pays, 34 bte L1.03.0, Louvain-la-Neuve, B-1348, Belgium, francois.glineur@uclouvain.be, Adrien Taylor, Julien Hendrickx

The worst-case performance of a black-box first-order method can be obtained as the solution of an optimization problem over sets of (smooth) (strongly) convex functions. We develop closed-form necessary and sufficient conditions for (smooth) (strongly) convex interpolation, which provide a finite representation for those functions and allows us to reformulate the worst-case performance estimation problem as an equivalent finite dimension-independent semidefinite optimization problem. We describe several applications of this approach related to both its convex interpolation and performance estimation aspects.

2 - A Flexible ADMM Algorithm for Big Data Applications

Rachael E. H. Tappenden, Postdoctorate, John Hopkins University, Whitehead Hall, 3400 N Charles St, Baltimore, MD, 21218, United States of America, rachael.e.h.tappenden@gmail.com, Daniel P. Robinson

In this talk we present a flexible Alternating Direction Method of Multipliers (F-ADMM) algorithm for solving optimization problems involving a strongly convex objective function that is separable into n blocks, subject to linear equality constraints. The F-ADMM algorithm updates the blocks of variables in a Gauss-Seidel fashion, and the subproblems within F-ADMM include a regularization term. The algorithm is globally convergent. We also introduce a hybrid variant called H-ADMM that is partially parallelizable, which is important in a big data setting. Convergence of H-ADMM follows directly from the convergence properties of F-ADMM. We present numerical experiments to demonstrate the practical performance of this algorithm.

3 - Complexity Bounds for Primal-Dual Methods Minimizing the Model of Objective Function

Yurii Nesterov, CORE, Voie du Roman Pays 34, Louvain-la-Neuve, Belgium, yurii.nesterov@uclouvain.be

We provide Frank-Wolfe (Conditional Gradients) method with a convergence analysis allowing to approach a primal-dual solution of convex optimization problem with composite objective function. Additional properties of complementary part of the objective (strong convexity) significantly accelerate the scheme. We also justify a new variant of this method, which can be seen as a trust-region scheme applying the linear model of objective function. Our analysis works also for a quadratic model, allowing to justify the global rate of convergence for a new second-order method. To the best of our knowledge, this is the first trust-region scheme supported by the worst-case complexity bound.

■ MC02

02- Grand 2

Power Systems: Operations and Planning

Cluster: Optimization in Energy Systems

Invited Session

Chair: Jean-Paul Watson, Distinguished Member of Technical Staff, Sandia National Laboratories, P.O. Box 5800, MS 1326, Albuquerque, NM, 87185, United States of America, jwatson@sandia.gov

1 - A Scalable Solution Framework for Stochastic Transmission and Generation Planning Problems

Francisco Munoz, Postdoctoral Appointee, Sandia National Laboratories, 1700 Indian Plaza Dr NE Apt 5, Albuquerque, NM, 87106, United States of America, fdmunoz@sandia.gov, Jean-Paul Watson

Current commercial software tools for transmission and generation investment planning have limited stochastic modeling capabilities. We propose a scalable decomposition algorithm to solve stochastic transmission and generation planning problems. Given stochasticity restricted to loads and wind, solar, and hydro power output, we develop a simple scenario reduction framework based on a clustering algorithm, to yield a more tractable model. The resulting stochastic optimization model is decomposed on a scenario basis and solved using a variant of the Progressive Hedging (PH) algorithm. The results indicate that large-scale problems (e.g., WECC 240-bus system) can be solved to a high degree of accuracy in at most 2 h of wall clock time.

2 - Impact of ACOPF Constraints on Security-Constrained Unit Commitment

Anya Castillo, Researcher, JHU/FERC, 5712 Yellowrose Court, Columbia, MD, 21045, United States of America, anya.castillo@gmail.com, Jean-Paul Watson, Cesar Silva-Monroy, Carl Laird

Because operational constraints on thermal units require these resources to be committed in advance of when they are needed, system operators solve a unit commitment optimization problem in the day-ahead. At times, certain out-of-merit units need to be committed for reliability reasons. Typically such units are committed in a reliability run and subsequently would receive make-whole payments so that market participants are not forced to operate at a loss. Ideally the more operational constraints and physical limitations (which would affect real-time dispatch) included in the day-ahead unit commitment optimization problem, the better convergence between day-ahead and real-time pricing. We propose a SCUC+ACOPF approach in this work.

3 - Scalable Lower and Upper Bounding Techniques for Stochastic Unit Commitment

Jean-Paul Watson, Distinguished Member of Technical Staff, Sandia National Laboratories, P.O. Box 5800, MS 1326, Albuquerque, NM, 87185, United States of America, jwatson@sandia.gov

We describe configurations of a scenario-based decomposition strategy for solving the stochastic unit commitment problem, based on the progressive hedging algorithm. We consider both upper and lower bounding aspects of progressive hedging, and demonstrate parameterizations that yield extremely tight optimality gaps (<0.1%) for 100-generator cases and moderately tight optimality gaps (<1.0%) for 350-generator cases. Using modest scale (cluster) parallelism, we are able to achieve this performance in less than 15 minutes of wall clock time.

■ MC03

03- Grand 3

Approximation Algorithms for Clustering Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Viswanath Nagarajan, University of Michigan, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, viswa@umich.edu

1 - Padded Decomposition for Minor-Free Graphs

Anupam Gupta, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, anupamg@cs.cmu.edu

We prove that given a graph G excluding Kr as a minor, and a diameter bound D, G can be partitioned into clusters of diameter at most D while removing at most O(r/D) fraction of the edges. This improves over the results of Fakcharoenphol and Talwar, who building on the work of Klein, Plotkin and Rao gave a partitioning that required to remove O(r^2/D) fraction of the edges.

2 - The Euclidean k-Supplier Problem

Baruch Schieber, IBM Research, TJ Watson Research Center, P.O. Box 218, Yorktown Heights, NY, 10598, United States of America, sbar@us.ibm.com, Viswanath Nagarajan, Hadas Shachnai

In the k-supplier problem, we are given a set of clients and set of facilities located in a metric space along with a bound k. The goal is to open a subset of k facilities so as to minimize the maximum distance of a client to an open facility. We present a 1+sqrt(3)<2.74 approximation algorithm for the k-supplier problem in Euclidean metrics. This improves the known 3-approximation algorithm which also holds for general metrics (where it is known to be tight). It has been shown that it is NP-hard to approximate Euclidean k-supplier to better than a factor of sqrt(7) (approximately 2.65). We also present an O(n log^2 n) time algorithm for Euclidean k-supplier in constant dimensions that achieves an approximation ratio of 2.965.

3 - On Uniform Capacitated k-Median Beyond the Natural LP Relaxation

Shi Li, Toyota Technological Institute at Chicago, 6045 S Kenwood Ave, Chicago, IL, 60637, United States of America, shili@ttic.edu

We study the uniform capacitated k-median problem. Obtaining a constant approximation algorithm for this problem is a notorious open problem. Most previous works are based on the natural LP-relaxation for the problem, which has unbounded integrality gap, even when we are allowed to violate the capacity constraint or the cardinality constraint by a factor of 2-epsilon. We give an exp(O(1/epsilon^2))-approximation algorithm for the problem that violates the cardinality constraint by a factor of 1+\epsilon. This is already beyond the capability of the natural LP relaxation, as it has unbounded integrality gap even if we are allowed to open (2-epsilon)k facilities. Indeed, our result is based on a novel LP for this problem.

■ MC04

04- Grand 4

Geometry, Duality, and Complexity in Convex Optimization II

Cluster: Conic Programming

Invited Session

Chair: Gabor Pataki, University of North Carolina at Chapel Hill, Chapel Hill, NC, Chapel Hill, United States of America, gabor@unc.edu

1 - On the Conditioning and Geometry of Convex Optimization Problems

Javier Pena, Professor of Operations Research, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, jfp@andrew.cmu.edu, Daniel Rodriguez, Negar Soheili, Vera Roshchina

The behavior of various algorithms for convex optimization problems can be analyzed in terms of condition measures associated to the geometry of the problem. We provide novel insights into the interplay between problem conditioning, problem geometry, and the speed of convergence of algorithms for convex optimization. We illustrate these insights via recent developments on problem preconditioning and on variants of the Frank-Wolfe, von Neumann, and perceptron algorithms.

2 - Exact Duality and Exact, Short Certificates in Conic Linear Programming

Minghui Liu, UNC Chapel Hill, Department of Statistics, and Operations Research, Chapel Hill, NC, 27599, United States of America, minghuil@live.unc.edu, Gabor Pataki

In conic linear programming, unlike in linear programming, the simplest version of Farkas' lemma may not prove infeasibility. We describe our progress in finding exact duals, and exact short certificates of infeasibility in conic LPs, which are nearly as simple as Farkas' lemma in linear programming. We describe an algorithm to generate infeasible SDPs, and present computational results on our set of test problems using commercial and research codes. The first part of this talk (which can be understood independently) is presented by Gabor Pataki.

3 - Facial Reduction for Cone Optimization

Henry Wolkowicz, Professor, University of Waterloo, Faculty of Mathematics, Waterloo, ON, N2L3G1, Canada, hwolkowi@uwaterloo.ca, Yuen-Lam Voronin, Nathan Krislock, Dmitriy Drusvyatskiy

The Slater constraint qualification (SCQ) is essential for many classes of convex programs. However, SCQ fails for many problems, e.g., for many instances of semidefinite programming (SDP) that arise from relaxations of computationally hard problems. A theoretical tool to regularize these problems uses facial reduction. We consider several specific applications where the structure of the problem surprisingly allows us to exploit this degeneracy. Rather than presenting numerical difficulties, we obtain smaller stable problems that allow for efficient high accuracy solutions for many large scale instances. In particular, we look at facial reduction for sensor network localization (SNL) and molecular conformation (MC).

■ MC05

05- Kings Garden 1

Advances in Continuous Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Dominique Orban, GERAD and Ecole Polytechnique, 3000, ch. de la Cote-Sainte-Catherine, Montreal, Canada, dominique.orban@gerad.ca

1 - On the Behavior of the Method of Conjugate Gradients and Quasi-Newton Methods on Quadratic Problems

Anders Forsgren, KTH Royal Institute of Technology, Department of Mathematics, Stockholm, SE-10044, Sweden, andersf@kth.se, Tove Odland

In this talk we discuss the behavior of the method of conjugate gradients and quasi-Newton methods on a quadratic problem. In particular, we give necessary and sufficient conditions for the methods to generate identical iterates. We show that the set of quasi-Newton schemes that generate parallel search directions to those of the method of conjugate gradients is strictly larger than the one-parameter Broyden family. In addition, we show that this set contains an infinite number of symmetric rank-one update schemes. We also extend the dicussion to the behavior of unnormalized Krylov subspace methods on singular systems.

2 - ARCq: A New ARC Variant and Its Simple Convergence Proofs Unified with Trust Region Methods

Jean-Pierre Dussault, Université de Sherbrooke, 2500 Blvd Université, Sherbrooke, QC, j1k2r1, Canada, Jean-Pierre.Dussault@USherbrooke.ca

We provide a simple convergence analysis unified for TR and a new ARC algorithms, which we name ARCq and which is very close in spirit to trust region methods, closer than the original ARC is. We prove global convergence to second order points. We also obtain as a corollary the convergence of the original ARC method. Since one of our aims is to achieve a simple presentation, we sacrifice some generality which we discuss at the end of our developments. In this simplified setting, we prove the optimal complexity property for the ARCq and identify the key elements which allow it. We end by proposing an efficient implementation using a Cholesky like factorization.

3 - Linear Algebra for Matrix-Free Optimization

Dominique Orban, GERAD and Ecole Polytechnique, 3000, ch. de la Cote-Sainte-Catherine, Montreal, Canada, dominique.orban@gerad.ca

When formulated appropriately, the broad families of sequential quadratic programming, augmented Lagrangian and interior-point methods all require the solution of symmetric saddle-point linear systems. When regularization is employed, the systems become symmetric and quasi definite. The latter are indefinite but their rich structure and strong relationships with definite systems enable specialized linear algebra, and makes them prime candidates for matrix-free implementations of optimization methods. In this talk, we explore various formulations of the step equations in optimization and corresponding iterative methods that exploit their structure.

■ MC06

06- Kings Garden 2

Energy and Optimization

Cluster: Optimization in Energy Systems

Invited Session

Chair: Leonardo Taccari, Politecnico di Milano, via Ponzio 34/5, Milano, MI, 20133, Italy, leonardo.taccari@polimi.it

1 - Approximate Dynamic Programming using Dynamic Quantile-Based Risk Measures for Energy Bidding

Daniel Jiang, Princeton University, Sherrerd Hall, Charlton Street, Princeton, NJ, 08540, United States of America, drjiang@princeton.edu, Warren Powell

We consider a finite-horizon Markov decision process (MDP) for which the objective at each stage is to minimize a quantile-based risk measure of the sequence of future costs. In particular, we consider optimizing dynamic risk measures constructed using the one-step quantile (or value at risk) and the one-step conditional value at risk (CVaR). Although there is considerable theoretical development of risk-averse MDPs in the literature, the computational challenges have not been explored as thoroughly. We propose simulation-based approximate dynamic programming (ADP) algorithms, modeled after Q-learning. We also present numerical results by applying the algorithms in the context of an application to bidding in the energy market.

2 - Robust Mixed-Integer Optimization Approaches for Operational Planning of Energy Systems with Storage

Leonardo Taccari, Politecnico di Milano, via Ponzio 34/5, Milano, MI, 20133, Italy, leonardo.taccari@polimi.it

Planning the operations of energy systems is a classical problem where, given a time horizon, one aims to find a production schedule minimizing the cost while satisfying given demands and technical constraints. We focus on problems where the generated energy can be stored from one period to the following, e.g., unit commitment in microgrids with battery banks, or cogeneration systems with storage tanks for thermal energy. Finding a plan which is robust with respect to the uncertainties that may arise in the demand is crucial. In this work, we study robust mixed-integer optimization approaches that can be used in problems with fixed costs and constraints such as ramping and minimum up/downtime, and test them on real-world instances.

3 - Performance Bounds for Look-Ahead Power System Dispatch using Generalized Multi-Stage Policies

Paul Beuchat, PhD Candidate, ETH Zürich, Physikstrasse 3, Zurich, ZH, 8092, Switzerland, beuchatp@control.ee.ethz.ch, Joseph Warrington, Manfred Morari, Tyler Summers

We present a combined look-ahead dispatch and reserve optimization formulation, which extends our recent work on time-coupled reserve policies, and employs the recent notion of generalized decision rules from the robust optimization literature. This aims to improve the performance of traditional linear decision rules when applied to short-term electrical reserve operation. We derive a primal problem whose solution is a time-coupled policy for the reserve dispatch. We derive also an associated dual problem that allows the sub-optimality of a candidate solution, based on a particular decision rule parameterization, to be bounded. We demonstrate the method using a numerical case study on the standard IEEE-118 bus network.

■ MC07

07- Kings Garden 3

Software Components for Large-Scale Engineering Optimization

Cluster: Implementations and Software

Invited Session

Chair: Bart Van Bloemen Waanders, Sandia National Laboratories, P.O. Box 5800, Albuquerque, United States of America, bartv@sandia.gov

1 - The Identifiability Approach for Time-Dependent Full Waveform Inversion

Drosos Kourounis, Universita della Svizzera italiana, drosos.kourounis@usi.ch

Full-waveform inversion (FWI) has been considered the next logical step in deriving velocity models. Despite advances in computing, it still remains a computationally demanding problem due to the huge number of geological parameters. A mathematical approach is described using interior-point and sequential quadratic programming methods for identifiable parameter subsets. The suggested approach results in significantly reduced number of parameters, avoidance of local minima through second order information, and decreased computational complexity.

2 - Sundance: Unified Embedded Parallel Finite Element Computations and Analysis

Kevin Long, Texas Tech University, kevin.long@ttu.edu

Analysis of partial differential equations requires not only forward solutions, but the extraction of sensitivities with respect to input parameters. Moving beyond automating PDE solutions, we present a framework that unifies the discretization of PDEs with analysis requirements. In particular, Frechet differentiation on a class of functionals together with a high-performance, finite element framework have led to Sundance. The software provides high-level programming abstractions for finite variational forms together with operators required by analysis.

3 - Rapid Optimization Library (ROL)

Bart Van Bloemen Waanders, Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM, United States of America, bartv@sandia.gov, Denis Ridzal, Drew Kouri

We present a large-scale nonlinear optimization capability in Trilinos, called Rapid Optimization Library (ROL). ROL implements hardened, production-ready, parallel-capable algorithms for unconstrained and constrained optimization. ROL features efficient use of application data structures and solvers, unified interfaces for simulators, methods for inexact computations, and algorithms to perform optimization under uncertainty. We explore reduced and full-space formulations of simulation-based optimization problems through various numerical examples and present a summary of ROL's use within Sandia's production simulators.

■ MC08

08- Kings Garden 4

Homomorphisms, Fast Algorithms and Limits

Cluster: Combinatorial Optimization

Invited Session

Chair: Jaroslav Nesetril, Professor, Computer Science Institute of Charles University, Malostranske nam.25, Prague, 11800, Czech Republic, nesetril@kam.mff.cuni.cz

1 - List Homomorphisms, Time and Space

Pavol Hell, Professor, Simon Fraser University, University Drive, Burnaby, BC, V5A1S6, Canada, pavol@cs.sfu.ca

I will describe some recent results on the time and space complexity of the list homomorphism problem for directed graphs. This is joint work with Arash Rafiey, Benoit Larose, L·szlo Egri, and Victor Dalmau.

2 - Fast Algorithms for Sparse Combinatorial Problems

Jaroslav Nesetril, Professor, Computer Science Institute of Charles University, Malostranske nam.25, Prague, 11800, Czech Republic, nesetril@kam.mff.cuni.cz, Patrice Ossona de Mendez

On the background of Nowhere dense vs Somewhere dense dichotomy (which can be expressed in a very simple way) we list several linear and almost linear algorithms for both decision and counting problems. The question of (relativised) first order definability leads to interesting approach to some old combinatorial problems.

3 - Limits and Approximations of Maps

Patrice Ossona de Mendez, Researcher, CNRS and Charles University, CAMS - EHESS, 190 avenue de France, Paris, 75013, France, pom@ehess.fr, Jaroslav Nesetril

Structural convergence is defined as the convergence, for each first-order formula in a specific fragment of first-order logic, of the satisfaction probability. This extends both Lovasz-Szegedy left-convergence of graphs and Benjamini-Schramm local-convergence of graphs with bounded degree. In this setting, we consider structural limits of finite maps. Conversely, we address the problem of approximating Borel maps by finite maps, and discuss connections with Aldous-Lyons conjecture on the approximation of graphings by finite graphs.

■ MC09

09- Kings Garden 5

Extended Formulations and the Matching Problem

Cluster: Combinatorial Optimization

Invited Session

Chair: Sebastian Pokutta, 400 Ferst Drive, Atlanta, GA, 30318, United States of America, sebastian.pokutta@isye.gatech.edu

1 - The Matching Polytope has Exponential Extension Complexity

Thomas Rothvoss, University of Washington, Seattle, WA, United States of America, rothvoss@uw.edu

A popular method in combinatorial optimization is to express polytopes P, which may potentially have exponentially many facets, as solutions of linear programs that use extra variables to reduce the number of constraints down to a polynomial. Recent years have brought amazing progress in showing lower bounds for the so called extension complexity, which for a polytope P denotes the smallest number of necessary inequalities. However, the central question in this field remained wide open: can the perfect matching polytope be written as an LP with polynomially many constraints? We answer this question negatively. In fact, the extension complexity of the perfect matching polytope in a complete n-node graph is 2^Omega(n).

2 - Quantum Communication Complexity as a Tool to Analyze PSD Rank

Ronald de Wolf, Professor, CWI and University of Amsterdam, Science Park 123, Amsterdam, 1098 XG, Netherlands, Ronald.de.Wolf@cwi.nl

We start with a brief introduction to quantum communication complexity, and then describe the connection with the positive-semidefinite rank of matrices (Fiorini et al'12): the logarithm of the psd rank of a matrix M equals the minimal quantum communication needed by protocols that compute M in expectation. Hence results about quantum communication complexity imply results about psd rank. As an example we present an efficient quantum communication protocol (Kaniewski, Lee, de Wolf'14) that induces an exponentially-close approximation for the slack matrix for the perfect matching polytope, of psd rank only roughly exp(sqrt{n}). In contrast, Braun and Pokutta'14 showed that even 1/n-approximating matrices need nonnegative rank exp(n).

3 - Matching has no Fully-Polynomial Size Linear Programming Relaxation Scheme

Gabor Braun, H. Milton Stewart School of Industrial & Systems Engineering at Georgia Tech, gabor.braun@isye.gatech.edu, Sebastian Pokutta

Rothvofl [T. Rothvofl, The matching polytope has exponential extension complexity. STOC, 263-272, 2014] established that every linear program for the matching polytope has exponential many inequalities. We generalize this to sharp bounds on polyhedral inapproximability of the matching polytope: for 0 < e < 1, every polyhedral (1 + e/n)-approximation requires exponential many inequalities, where n is the number of vertices. Thus matching is the first problem in P, whose natural linear encoding does not admit a fully polynomial-size relaxation scheme (the polyhedral version of FPTAS). Our approach reuses Rothvofl's ideas, but the main lower bounding tool is common information instead of the hyperplane separation bound.

■ MC10

10- Kings Terrace

Timetabling and Rostering in Transportation

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Mizuyo Takamatsu, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, takamatsu@ise.chuo-u.ac.jp

1 - Optimal Duty Rosters for Toll Enforcement Inspectors

Elmar Swarat, PhD Student, Zuse-Institute Berlin, Takustr. 7, Berlin, D-14195, Germany, swarat@zib.de, Thomas Schlechte, Stephan Schwartz

We consider the problem of computing optimal duty rosters for toll enforcement inspectors on German motorways. This leads to an integrated vehicle routing and duty rostering problem. The model is based on a planning graph, where rosters correspond to paths. A path models a sequence of duties and days-off, respecting several legal constraints. The duties consist of best rated control tours. According to several modeling issues this problem can be solved directly by an Integer Program based on arc variables. A computational study from real-world operation will analyse the solution behaviour.

2 - Timetabling and Passenger Routing in Public Transport

Heide Hoppmann, Zuse Institute Berlin, Takustrafle 7, Berlin, 14195, Germany, hoppmann@zib.de

In timetabling, periodic arrival and departure times of lines in a public transport system are scheduled. One objective of optimization models for timetabling is to minimize the travel time for the passengers. However, the models are generally based on fixed passenger routes and, hence, ignore potentially valuable degrees of freedom. We investigate periodic timetabling models with integrated passenger routing, compare different variants of routings, and present computational results for the city of Wuppertal.

3 - Bus Timetable Design in Areas with Low-Frequency Public Transportation Services

Mizuyo Takamatsu, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, takamatsu@ise.chuo-u.ac.jp, Azuma Taguchi

In Japan, rural areas face with sparsity in population and rapid growth of the percentage of elderly people. In these areas, a lot of bus lines have less than ten services in a day. Besides low-frequency services, it is also inconvenient to transfer to another bus service or train service. Thus, there is a strong need to design a timetable which ensures smooth transfer among buses and trains. We tackle this problem not from scratch, but by inheriting the existing bus lines and train timetables as much as possible. Based on the approach, we present a mathematical optimization model to generate a bus timetable which achieves shorter waiting time for transfer than the current timetable, and apply the model to the Tohoku district in Japan.

■ MC11

11- Brigade

Graph Theory

Cluster: Combinatorial Optimization

Invited Session

Chair: Jan Kratochvil, Charles University, Prague, Czech Republic, honza@kam.mff.cuni.cz

1 - The Structure of Even-Hole-Free Claw-Free Graphs

Kathie Cameron, Professor, Wilfrid Laurer University, Department of Mathematics, 75 University Avenue West, Waterloo, On, N2M2M6, Canada, kcameron@wlu.ca, Chinh Hoang, Steven Chaplick

A hole is an induced cycle with at least four vertices. An apple is a hole with a pendant edge. Apple-free graphs generalize claw-free graphs which generalize line-graphs, and thus independent sets in apple-free graphs generalize matchings. Minty's (1980) polytime algorithm for max weight independent set in claw-free graphs led to much research on claw-free graphs, including its generalization to apple-free graphs by Brandstadt, Lozin and Mosca (2010). Coloring line-graphs is NP-hard. We show a graph is apple-free even-hole free if and only if it can be decomposed by clique cutsets into joins of cliques and unit circular-arc graphs. This provides polytime algorithms for recognizing apple-free even-hole-free graphs and for min coloring them.

2 - Decomposition Theorems for Square-Free 2-Matchings in Bipartite Graphs

Kenjiro Takazawa, Assistant Professor, Kyoto University, Oiwake-cho, Kitashirakawa, Sakyo-ku, Kyoto, 606-8502, Japan, takazawa@kurims.kyoto-u.ac.jp

A square-free 2-matching in a bipartite graph is a simple 2-matching without cycles of length four. In this talk, we present new decomposition theorems for square-free 2-matchings in bipartite graphs. These theorems serve as an analogue of the Dulmage-Mendelsohn decomposition and the Edmonds-Gallai decomposition. We exhibit two canonical minimizers for the set function in the min-max formula, and a characterization of the maximum square-free 2-matchings with the aid of these canonical minimizers.

3 - Polyhedral and Computational Results on the k-hop Connected Dominating Set Problem

Phablo Fernando Soares Moura, PhD Student, University of São Paulo, Rua do Matão 1010, Cidade Universitaria, São Paulo, SP, 05508-090, Brazil, phablo@ime.usp.br, Rafael Santos Coelho, Yoshiko Wakabayashi

For a connected graph G and a positive integer k, a subset D of the vertices of G is called a k-hop connected dominating set if D induces a connected subgraph of G and, for every vertex v in G, there is a vertex u in D such that the distance between v and u in G is at most k. We study the minimum k-hop connected dominating set problem. An integer linear programming formulation is presented with some classes of inequalities that define facets of the corresponding polytope. We also report computational results on a branch-and-cut algorithm.

■ MC12 1:10pm - 1:50pm

12- Black Diamond

SAS – Building and Solving Optimization Models with SAS

Cluster: Software Presentations

Invited Session

Chair: Ed Hughes, SAS, ed.hughes@sas.com

1 - SAS - Building and Solving Optimization Models with SAS

Ed Hughes, SAS, ed.hughes@sas.com

SAS provides comprehensive data and analytic capabilities, including statistics, data/text mining, forecasting, and operations research methods: optimization, simulation, and scheduling. OPTMODEL from SAS provides a powerful and intuitive algebraic optimization modeling language, with unified support for LP, MILP, QP, NLP, CLP, and network-oriented models. We'll demonstrate OPTMODEL, highlighting its newer capabilities and its support for standard and customized solution approaches, working through sample problems and exploring multiple modeling and solution approaches for each.

■ MC13

13- Rivers

Conic Optimization: Algorithms and Applications

Cluster: Conic Programming

Invited Session

Chair: Miguel Anjos, Professor and Canada Research Chair, Polytechnique Montreal, C.P. 6079, Succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, miguel-f.anjos@polymtl.ca

1 - Solution Approaches for Equidistant Double- and Multi-row Facility Layout Problems

Philipp Hungerländer, Alpen-Adria-Universitaet Klagenfurt, philipp.hungerlaender@aau.at, Anja Fischer, Miguel Anjos

We consider the multi-row equidistant layout problem in which equidistant departments are to be placed on a given number of rows so that the sum of the weighted center-to-center distances is minimized. We prove two theoretical results. First we show that although the lengths of the spaces between the departments are in general continuous quantities, every multi-row equidistant problem has an optimal solution on the grid and hence only spaces of unit length need to be used when modeling the problem. Second we give exact expressions for the minimum number of spaces that need to be added so as to preserve at least one optimal solution. We exploit these results to tailor exact approaches that outperform other recent methods for this problem.

2 - Second-order Cone Approximations for Optimal Power Flow Problems

Bissan Ghaddar, IBM Research, Damastown Industrial Estate, Mulhuddart, Dublin 15, Dublin, Ireland, bghaddar@ie.ibm.com, Xiaolong Kuang, Luis Zuluaga, Joe Naoum-Sawaya

Semidefinite programming (SDP) relaxations for general polynomial optimization problems based on sum of squares polynomials have been shown to be tight. Due to the computational challenge of solving positive semidefinite problems, it becomes difficult to use SDP for large-scale problems and for high order relaxations. In this work, we exploit recent results in polynomial optimization to construct a hierarchy of second-order cone relaxations and we evaluate the proposed approach on Optimal Power Flow problems. We show that in comparison to the SDP-based hierarchies, the second-order cone hierarchies provide global bounds on large-scale optimal power flow problems where SDP hierarchies fail.

3 - Novel Family of Cuts for SDP Relaxations for Some Classes of Binary Quadratic Optimization Problems

Elspeth Adams, École Polytechnqiue de Montreal, 2900, Boul. Édouard-Montpetit, Montreal, QB, H3T 1J4, Canada, elspeth.adams@polymtl.ca, Miguel Anjos

k-projection polytope constraints (kPPCs) are a family of constraints that tighten SDP relaxations using the inner description of small polytopes, as opposed to the typical facet description. We examine the properties of kPPCs, methods for separating violated kPPCs and their impact on the bounds in a cutting plane algorithm. Problems satisfying the required projection property, such as the max-cut and stable set problems, will be considered and results will focus on large instances.

■ MC14

14- Traders

Auctions and Mechanism Design

Cluster: Game Theory

Invited Session

Chair: Ozan Candogan, Duke University, Fuqua School of Business, Durham, NC, 27705, United States of America, ozan.candogan@duke.edu

1 - Customer Referral Incentives and Social Media

Ilan Lobel, New York University, 44 W 4th St, New York, NY, United States of America, ilobel@stern.nyu.edu, Evan Sadler, Lav Varshney

We study how to optimally attract new customers using a referral program. Whenever a consumer makes a purchase, the firm gives him or her a link to share with friends, and every purchase coming through that link generates a referral payment for the consumer. The firm chooses the referral payment function, and consumers respond by playing an equilibrium. The optimal payment function is nonlinear and not necessarily monotonic. If we approximate the optimal policy using a linear payment function, the approximation loss scales with the square root of the average consumer degree. Using a threshold payment, the loss scales proportionally to the average degree. Combining the two, we achieve a constant bound on the approximation loss.

2 - Dynamic Mechanism Design with Budget Constrained Buyers

Omar Besbes, Columbia University, New York, United States of America, ob2105@columbia.edu, Santiago Balseiro, Gabriel Weintraub

We consider the problem of a seller who has a number of perishable items arriving sequentially over a time and who sells these items to a group of budget constrained buyers. We formulate the problem as a dynamic mechanism design problem with no commitment power. We argue that this problem is generally intractable. Thus motivated, we introduce a continuous time fluid model that allows for a tractable characterization of the optimal dynamic mechanism.

3 - Structures of Optimal Policies in Dynamic Mechanism Design with One Agent

Peng Sun, Fuqua School of Business, 100 Fuqua Drive, Fuqua School Of Business, Duke Universit, Durham, NC, 27708, United States of America, peng.sun@duke.edu, Bingyao Chen, Alex Belloni

A principal procures up to one unit of a product in every period from an agent who is privately informed about its marginal production cost in each period. We allow a non-negative fixed cost in each period. We consider two dynamic models, distinguished by whether the agent allows promises of future payments. Under mild regularities conditions on the distribution of the production cost, we show that the optimal contract in both models offers at most two different procurement levels in each period depending on the newly reported production cost. This yields tractable computational procedures. Our results rely on the analysis of the "dynamic virtual valuation," a generalization of the Myersonian virtual valuation in the static setting.

■ MC15

15- Chartiers

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: Dusan Jakovetic, Biosense Center, University of Novi Sad, Ul. Zorana Djindjica 1, Novi Sad, Serbia-Montenegro, dusan.jakovetic@gmail.com

1 - Convergence Rate of Incremental Aggregated Gradient Algorithms

Mert Gurbuzbalaban, Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Boston, MA, 02139, United States of America, mertg@mit.edu, Asu Özdaglar, Pablo Parrilo

We analyze the incremental aggregated gradient method for minimizing a sum of strongly convex functions from a novel perspective, simplifying the global convergence proofs considerably and proving a new linear rate result. We also develop a class of alternative aggregated methods, provide their linear rate and analyze the trade-off between the convergence rate and the memory requirement. We finally discuss applications to distributed asynchronous optimization and large-scale data processing.

2 - Distributed Gradient Methods with Variable Number of Working Nodes

Dusan Jakovetic, Biosense Center, University of Novi Sad, Ul. Zorana Djindjica 1, Novi Sad, Serbia-Montenegro, dusan.jakovetic@gmail.com, Dragana Bajovic, Natasa Krejic, Natasa Krklec Jerinkic

We consider distributed optimization where N networked nodes minimize the sum of their local costs subject to a common constraint set. We propose a distributed projected gradient method where each node, at each iteration k, performs an update (is active) with probability p_k, and stays idle with probability 1-p_k. We show that, as long as p_k grows to one asymptotically, our algorithm converges in the mean square sense to the same solution as the standard distributed gradient method, i.e., as if all nodes were active at all iterations. Moreover, when p_k grows to one linearly, with appropriately set convergence factor, the algorithm has a linear convergence, with practically the same factor as the standard distributed gradient method.

3 - Implementation of Nonlinear Optimization Solver with Multiple Precision Arithmetic

Hiroshige Dan, Kansai University, 3-3-35, Yamate-cho, Suita-shi, Osaka, Japan, dan@kansai-u.ac.jp

Double precision arithmetic for nonlinear optimization problems (NLP) basically works well, but it sometimes fails to solve some ill-posed problems. On the other hand, multiple precision arithmetic has attracted much attention recently as a brute-force method for avoiding numerical errors. In this research, we have implemented an optimization solver for NLP by using multiple precision arithmetic and checked the advantage of multiple precision arithmetic for NLP through numerical results.

■ MC16

16- Sterlings 1

Advances in Integer Programming II

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - Investigating Mixed-integer Hulls using a MIP-solver

Matthias Walter, Otto-von-Guericke-Universitaet Magdeburg, Universitaetsplatz 2, Magdeburg, 39106, Germany, matthias.walter@ovgu.de, Volker Kaibel

A software tool is presented which, given a mixed-integer program, investigates the associated mixed-integer hull. In particular, it detects all equations and some facets valid for the hull with exact arithmetic. The facets are produced in such a way that they are helpful in optimizing the given objective function. This is in contrast to usual convex-hull algorithms which produce the entire description of the hull, but run out of resources for small dimensions already. The software can handle larger dimensions as it is based on solving MIPs. In particular, the facet computation is done using target cuts, introduced by Buchheim, Liers and Oswald in 2008.

2 - On the Complexity of Separation for the mod-k Closure

Jeff Pavelka, ISyE, Georgia Institute of Technology, 765 Ferst Drive, Atlanta, GA, 30332, United States of America, jpavelka@gatech.edu, Sebastian Pokutta

In integer programming, mod-k cuts are Chvatal-Gomory cuts where each multiplier is of the form a/k, with a being a nonnegative integer less than k. These cuts are well-studied in the case k=2, where it is known that finding a mod-2 cut which separates a given point from a polyhedron P is an NP-complete problem. We show that this result holds for any k, even in the case where P is contained in the 0-1 hypercube.

3 - Machine Learning to Balance the Load in Parallel Branch-and-Bound

Alejandro Marcos Alvarez, PhD Student, Université de Liège, Institut Montefiore (B28), 10 Grande Traverse, Liège, 4000, Belgium, amarcos@ulg.ac.be, Quentin Louveaux, Louis Wehenkel

We describe a new approach to parallelize branch-and-bound. We propose to split the optimization of the original problem into the optimization of several subproblems that can be optimized separately. The main innovation of our approach consists in the use of machine learning to create a function able to estimate the difficulty (number of nodes) of a subproblem of the original problem. These estimates are then used to decide how to partition the original optimization tree into a given number of subproblems, and how to distribute them among the available processors. Our experiments show that our approach succeeds in balancing the amount of work between the processors, and that interesting speedups can be achieved with little effort.

■ MC17

17- Sterlings 2

Numerical Methods for Nonlinear Optimization I

Cluster: Nonlinear Programming

Invited Session

Chair: Ya-xiang Yuan,, Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Zhong Guan Cun Donglu 55, Haidian, Beijing, 100190, China, yyx@lsec.cc.ac.cn

1 - Methods for Special Structured Matrix Problems

Cong Sun, Beijing University of Post and Telecommunication, No 10, Xitucheng Road, Haidian, Beijing, 100876, China, suncong@lsec.cc.ac.cn

A special matrix problem is considered from the application in wireless communications. The objective function is approximated by a fraction function. The alternating minimization method is applied. Efficient methods are proposed for the subproblems as nonconvex quadratic constrained quadratic programming and those with orothogonality constraints, where KKT points or optimal solutions are guaranteed. Simulations show the superior performances of our proposed models and algorithms.

2 - Some New Results On The Convergence Of Multi-block Admm

Shiqian Ma, Assistant Professor, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, William M.W.Mong Engineering Building, Shatin, N.T., Hong Kong - PRC, sqma@se.cuhk.edu.hk

We present the following two new results regarding to the convergence of multi-block ADMM. (1) The existing results on sufficient conditions for guaranteeing convergence of multi-block ADMM typically require the strong convexity on parts of the objective. In our work, we show convergence and convergence rate results for the multi-block ADMM applied to solve certain N-block convex minimization problems without requiring strong convexity. (2) It is known that the 2-block ADMM globally converges with any penalty parameter, i.e., it is a parameter free algorithm. In our work, we show that the unmodified 3-block ADMM is also parameter free, when it is applied to solving a certain sharing problem, which covers many interesting applications.

3 - Optimality and Stability Conditions for Symmetric Evolutionary Games

Zhijun Wu, Professor, Iowa State University, Department of Mathematics, Ames, IA, 50014, United States of America, zhijun@iastate.edu, Min Wang, Wen Zhou

Evolutionary game theory has been applied successfully to modeling evolution of various biological or social systems. In this theory, species are considered as if they are players in a game, competing for survival and reproduction. A mathematical (game) model can then be established for the study of evolution of the species. In this talk, we will focus on symmetric evolutionary games and discuss the optimality and stability conditions of their solutions. We will show that their solutions can be obtained by solving a special class of optimization problems. A set of first- and second-order optimality and stability conditions can thus be derived. Applications to genetic selection games will also be demonstrated.

■ MC18

18- Sterlings 3

Nonlinear Programming Methods for Probabilistic Programming Problems

Cluster: Stochastic Optimization

Invited Session

Chair: Miguel Lejeune, Associate Professor, George Washington University, 2201 G St, NW, Funger Hall 406, Washington, DC, 20052, United States of America, mlejeune@gwu.edu

1 - Data-Driven Chance-Constrained Optimization via Kernel Smoothing: Effective NLP Initialization

Bruno A. Calfa, Graduate Student, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, United States of America, bacalfa@cmu.edu, Francisco Trespalacios, Anshul Agarwal, Scott J. Bury, John M. Wassick

We propose a data-driven, nonparametric approach to reformulate individual and joint chance constraints with right-hand side uncertainty into algebraic constraints. The approach consists of using kernel smoothing to approximate unknown “true” continuous probability density/distribution functions. An effective NLP initialization algorithm is proposed to speed up the solution of kernel-based joint chance-constrained problems. We employ the proposed algorithm to a large-scale, industrial production planning problem. Computational results show that the initialization algorithm reduces total solution times by factors of 1.2 to 5.6.

2 - Probabilistic Optimization via Approximate p-efficient Points and Bundle Methods

Wim van Ackooij, EDF R&D, 1 Avenue du Général de Gaulle, Clamart, 92141, France, wim.van.ackooij@gmail.com, Violette Berge, Welington de Oliveira, Claudia Sagastizabal

For problems when decisions are taken prior to observing the realization of underlying random events, probabilistic constraints are an important modelling tool if reliability is a concern. A key concept to numerically dealing with probabilistic constraints is that of p-efficient points. By adopting a dual point of view, we develop a solution framework that includes and extends various existing formulations. The unifying approach is built on the basis of a recent generation of bundle methods called with on-demand accuracy, characterized by its versatility and flexibility. Numerical results for several difficult probabilistically constrained problems confirm the interest of the approach.

3 - Asymptotic Analytic Approximation for Non-Convex Chance Constrained Optimization

Abebe Geletu, Academic and Research Staff, TU-Ilmenau, Faculty of Computer Science and Automati, Simulation and Optimal Processes Group, Ilmenau, 98963, Germany, abebe.geletu@tu-ilmenau.de, Armin Hoffmann, Pu Li, Michael Kloeppel

Chance constrained optimization (CCOPT) problems are known to be quite difficult to solve. This work uses a smooth parametric approximation function to approximately solve non-convex CCOPT problems by solving a sequence of deterministic nonlinear programming problems (NLP). The proposed method has the following features. The approximating function and its gradient are easier to evaluate and converge to the probability function and gradient of the chance constraint function, respectively. The feasible set of each NLP is a subset of the feasible set of CCOPT (a-priori feasibility). Any limit-point of optimal solutions of the sequence of NLPs is an optimal solution of the CCOPT. The method works for Gaussian/non-Gaussian random variables.

■ MC19

19- Ft. Pitt

Recent Advances in PDE-Constrained Optimization

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Stefan Ulbrich, Professor, TU Darmstadt, Dolivostr. 15, Darmstadt, Germany, ulbrich@mathematik.tu-darmstadt.de

1 - Accelerated Source-Encoding Full-Waveform Seismic Tomography

Christian Boehm, ETH Zürich, Sonneggstrasse 5, NO H 39.3, Zürich, Switzerland, christian.boehm@erdw.ethz.ch, Andreas Fichtner, Michael Ulbrich

Seismic tomography infers the material properties of the Earth based on the observation of seismograms. We present Newton-type methods for full-waveform inversion governed by the elastic wave equation that utilize source-encoding strategies to substantially reduce the computational costs. In particular, we accelerate the minimization of a sample average approximation model by using mini-batch Hessian information. Furthermore, we work with inexact gradient information based on a compressed forward wavefield to reduce the memory requirements. We present numerical examples from geophysical exploration in 2d and 3d.

2 - Constrained Optimization with Low-Rank Tensors and Applications to Parametric Problems with PDEs

Sebastian Garreis, TU Muenchen, Zentrum Mathematik, M1, Boltzmannstr. 3, Garching b. Muenchen, 85748, Germany, garreis@ma.tum.de, Michael Ulbrich

Low-rank tensor methods provide efficient representations and computations with multidimensional arrays. They can break the curse of dimensionality in contrast to other methods for dealing with systems with multiple parameters (e.g. sparse grid integration). We present algorithms for constrained nonlinear optimization using low-rank tensors and their application to optimal control of PDEs with uncertain parameters and to uncertainty quantification for parametrized variational inequalities. These methods are tailored to the usage of low-rank tensor arithmetics and thus allow solving huge problems in a reasonable amount of time.

3 - Optimal Control of PDAEs as Abstract DAEs of Index 1

Hannes Meinlschmidt, TU Darmstadt, Dolivostrasse 15, Darmstadt, 64293, Germany, meinlschmidt@mathematik.tu-darmstadt.de, Stefan Ulbrich

We consider optimal control problems constrained by Partial Differential-Algebraic Equations, given by possibly nonlinearly coupled systems of each a parabolic- and a quasi-stationary elliptic equation for two unknown functions (abstract DAEs on Banach spaces). An invertibility assumption on the differential operator for the elliptic equation classifies the DAE as an Index 1 system. In order to be able to treat state constraints complementing the control problem, we focus on continuous solutions for the PDAE system. The theory allows for weak regularity data, such as bounded coefficient functions and mixed boundary conditions on (weak) Lipschitz domains. It is complemented by a real-world example, the thermistor problem.

■ MC20

20- Smithfield

ADMM and Applications

Cluster: Nonsmooth Optimization

Invited Session

Chair: Hyenkyun WooDr., Korea Institute for Advanced Study, 85 Hoegiro, Dongaemun-gu, Seoul, Korea, Republic of, hyenkyun@gmail.com

1 - An Iterative Quadratic Method for Joint Representation Classification in Face Recognition

Liping Wang, Dr., Nanjing University of Aeronautics and Astronautics, 29#, Yu Dao Street, Nanjing, China., Nanjing, China, wlpmath@nuaa.edu.cn

In this presentation, a joint representation classification (JRC) for face recognition is proposed. Underlying assuming that multi-face pictures share a similar representation pattern, JRC codes all the query images simultaneously. Aligning all the testing samples in a matrix, joint coding is formulated to a generalized minimization. To uniformly solve the mixed optimization problem, an iterative quadratic method (IQM) is designed. IQM is proved to be a strict decreasing algorithm and a practical version is proposed for large-scale cases. Experimental results on four public datasets show that the JRC saves much computational work and achieves better performance in face recognition than state-of-the-arts.

2 - Robust Asymmetric Nonnegative Matrix Factorization

Hyenkyun Woo, Dr., Korea Institute for Advanced Study, 85 Hoegiro, Dongaemun-gu, Seoul, Korea, Republic of, hyenkyun@gmail.com, Haesun Park

The problems that involve separation of outliers and low rank in a given matrix have attracted a great attention in recent years. In this talk, we introduce a new formulation called linf-norm based nonnegative matrix factorization (NMF) for the outliers and low nonnegative rank separation problems. The main advantage of linf-norm in NMF is that we can control denseness of the low nonnegative rank factor matrices. However, we also need to control distinguishability of the vectors in the low nonnegative rank factor matrices for stable basis. For this, we impose asymmetric constraints, i.e., denseness condition on the coefficient factor matrix only. The proposed model with soft regularization shows advantages in various applications.

■ MC21

21-Birmingham

Recent Advances in Derivative-Free Optimization I: Global Convergence and Worst Case Complexity

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Zaikun Zhang, Dr., CERFACS-IRIT joint lab, CERFACS, 42 Avenue Gaspard Coriolis, Toulouse, 31057, France, zaikun.zhang@irit.fr

1 - Unconstrained Stochastic Optimization with Occasionally Dominating Non-i.i.d. Noise

Matt Menickelly, Lehigh University, 200 W. Packer Ave., Bethlehem, PA, 18015, United States of America, mjm412@lehigh.edu, Ruobing Chen, Katya Scheinberg

We present a very general framework for unconstrained stochastic optimization based on a standard trust region framework using random models. We make assumptions on the stochasticity of the objective function different from the typical assumptions of stochastic and simulation-based optimization. In particular, we assume that our models and function values satisfy quality conditions with some probability, but can be arbitrarily bad otherwise. We analyze the convergence of this general framework and present computational results for several classes of noisy functions, where noise is not iid and dominates the function values when it occurs. Our simple framework performs very well in that setting, while standard stochastic methods fail.

2 - A Derivative-Free Trust-Region Algorithm for Composite Nonsmooth Optimization

Geovani N. Grapiglia, Dr., geovani_mat@hotmail.com, Jinyun Yuan, Ya-xiang Yuan

A derivative-free trust-region algorithm is proposed for minimizing a composite nonsmooth function. Global convergence results and a function-evaluation complexity bound are proved. Numerical results with minimax problems are also reported.

3 - A Globally Convergent Method for Linearly Constrained Noisy Minimization

Deise Ferreira, University of Campinas, Rua Sergio Buarque de Holanda, 651,, Campinas, SP, 13083-970, Brazil, ra070609@ime.unicamp.br, Sandra Santos, Maria Diniz-Ehrhardt

In this work, we propose a new globally convergent derivative-free algorithm for solving linearly constrained noisy minimization problems. PSIFA (Pattern Search Implicit Filtering Algorithm) is the combination of a pattern-search approach applied to linearly constrained smooth minimization and the implicit filtering algorithm proposed by C. T. Kelley. Such a combination allows faster convergence, besides extending the range of applicability to noisy problems. Furthermore, we are free of the rational stencil required by the pattern search approach and the finite bounds required by the implicit filtering algorithm, as long as an alternative boundedness assumption is made. Numerical experimentation put the proposed algorithm into perspective.

■ MC22

22- Heinz

Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Tomas Bajbar, Karlsruhe Institute of Technology, Institute of Operations Research, Kaiserstrafle 12, Karlsruhe, 76131, Germany, bajbar@kit.edu

1 - Coercive Polynomials and their Newton Polytopes

Tomas Bajbar, Karlsruhe Institute of Technology, Institute of Operations Research, Kaiserstrafle 12, Karlsruhe, 76131, Germany, bajbar@kit.edu, Oliver Stein

We introduce the broad class of so-called gem regular multivariate polynomials and characterize their coercivity via conditions imposed on the vertex set of their Newton polytopes. For all gem irregular polynomials we introduce sufficient conditions for coercivity, too. We also establish necessary conditions for coercivity for a special class of gem irregular polynomials. We relate our results to the context of polynomial optimization theory and we illustrate our results with several examples.

2 - An Adaptive Directed Balanced Interval Method for Solving Global Optimization Problems

Sijie Liu, Graduate Student, University of Alabama, 714 1/2 12th St. B, Tuscaloosa, AL, 35401, United States of America, sliu28@crimson.ua.edu

Global optimization problems arise in many scientific fields that deals with finding the extremal value of a function in a domain of definition, subjective to various criteria. And the interval optimization techniques are designed to solve almost all types of global optimization problems including the “hard” problems by its strong capacity of providing rigorous bounds in the presence of round of errors. The adaptive directed balanced interval method is proved to improve the quality of the traditional interval computation result by dealing with the overestimation for the range of the functions. Results indicate that the proposed approach is alternative to be used to upgrade the current interval optimization algorithm.

■ MC23

23- Allegheny

Advances in Distributionally Robust Optimization

Cluster: Robust Optimization

Invited Session

Chair: Daniel Kuhn, EPFL, EPFL-CDM-MTEI-RAO, Station 5, Lausanne, Switzerland, daniel.kuhn@epfl.ch

Co-Chair: Wolfram Wiesemann, Imperial College Business School, South Kensington Campus, London, United Kingdom, ww@imperial.ac.uk

1 - Distributionally Robust Joint Chance Constraints with Conic Dispersion Measures

Vladimir Roitch, Imperial College London, 180 Queen’s Gate, London, SW7 2AZ, United Kingdom, vladimir.roitch@imperial.ac.uk, Wolfram Wiesemann, Grani Hanasusanto, Daniel Kuhn

We analyse the complexity of a class of distributionally robust joint chance constrained programs where the uncertain parameters are described through their mean values and through upper bounds on general dispersion measures. We derive a tractable problem reformulation when the dispersion measure is conic and uncertain parameters only affect the right-hand side vector of the chance constraint. We also show that the problem becomes intractable if the left-hand side coefficient matrix is affected by uncertainty or the support of the uncertain parameters is restricted to a polyhedron. We illustrate the effectiveness of our exact reformulation in numerical experiments and demonstrate its superiority over state-of-the-art approximation schemes.

2 - Beyond Normality: A Cross Moment-Stochastic User Equilibrium Model

Selin Damla Ahipasãoglu, Singapore University of Technology and Design, 8 Somapah Rd, Singapore, 487372, Singapore, ahipasãoglu@sutd.edu.sg, Rudabeh Meskarian, Thomas Magnanti, Karthik Natarajan

The Stochastic User Equilibrium (SUE) model predicts traffic equilibrium flow when users choose their perceived maximum utility paths while accounting for the effects of congestion due to users sharing links. Inspired by recent work on distributionally robust optimization, specifically a Cross Moment (CMM) choice model, we develop a new SUE model that uses the mean and covariance information on path utilities without the form of the distribution. Under mild conditions, the CMM-SUE exists and is unique. It provides both modeling flexibility and computational advantages over the well-known MNP-SUE (Multinomial Probit-SUE) model that require distributional (normality) assumptions to model correlation effects from overlapping paths.

3 - Data-Driven Distributionally Robust Optimization using the Wasserstein Metric

Peyman Mohajerin Esfahani, Dr, EPFL & ETH Zurich, Funkwiesenstrasse 100, Zurich, 8050, Switzerland, peyman.mohajerin@epfl.ch, Daniel Kuhn

Abstract: We consider stochastic programs where the distribution of the uncertain parameters is only observable through a finite training dataset. Using the Wasserstein metric, we construct a ball in the space of probability distributions centered at the uniform distribution on the training samples, and we seek decisions that perform best in view of the worst-case distribution within this Wasserstein ball. Under mild assumptions, the emerging distributionally robust optimization problem admits an exact tractable reformulation, and its solutions enjoy finite-sample performance guarantees. We show that our approach also offers a new interpretation of the popular regularization techniques in machine learning.

■ MC24

24- Benedum

Applications of MINLP

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Dimitri Papageorgiou, ExxonMobil, 1545 Route 22 East,, Annandale, NJ, 08801, United States of America, dimitri.j.papageorgiou@exxonmobil.com

1 - MIP Formulations for the Floor Layout Problem

Joey Huchette, MIT Operations Research Center, 411 Norfolk St, Unit 2C, Somerville, MA, 02143, United States of America, huchette@mit.edu, Juan Pablo Vielma, Santanu Dey

The floor layout problem is to find the best configuration of N rectangular boxes on a fixed rectangular floor, and has applications in VLSI and factory design. The boxes must have a certain area, but their dimensions can vary. We present a framework for generating mixed-integer second-order cone formulations for the problem, as well as a litany of cutting planes. We emphasize a new formulation that offers computational gains by pruning redundant integer solutions.

2 - Multi-Modal Transportation Network Design Problem Considering Sustainability

Metin Turkay, Professor. Dr., Koc University, Rumelifeneri Yolu, Sariyer, Istanbul, 34450, Turkey, mturkay@ku.edu.tr, Narges Shahraki

The multi-modal transportation network design problem integrates different transportation modes in fulfilling the uncertain transportation demand of different entities (passengers, industry, commerce etc.). We present a novel bi-level optimization problem: in the lower level, transportation design problem is formulated to minimize traveler costs and in the upper level we consider minimizing emissions. The two-stage model is formulated as a single-stage MINLP problem with 2 objectives by considering optimality condition of lower level problem as a set of constraints in the upper level model. An exact solution algorithm based on outer approximation and ?-constraint method is implemented to solve the problem.

3 - Multiperiod Blending: Formulations, Discretizations, and Decompositions

Dimitri Papageorgiou, ExxonMobil, 1545 Route 22 East, Annandale, NJ, 08801, United States of America, dimitri.j.papageorgiou@exxonmobil.com

The multiperiod blending problem arises in many petrochemical planning and scheduling applications. It involves binary variables and bilinear terms yielding a nonconvex MINLP that is challenging to solve both for feasibility and to optimality. We present three techniques to overcome these hurdles: Formulations with redundant constraints to improve the MILP relaxation of the MINLP; Discretization methods for improving time to feasibility; Decomposition methods that iteratively solve an MILP master problem and an MINLP subproblem. Computational results illustrate the benefits of these techniques over state-of-the-art general purpose solvers.

■ MC25

25- Board Room

Constraint-Based Scheduling II

Cluster: Constraint Programming

Invited Session

Chair: Philippe Laborie, IBM, 9, rue de Verdun, Gentilly, 94253, France, phi.laborie@free.fr

1 - A Constraint Programming Approach for Solving Convex Quadratically-Constrained Problems

Chris Beck, University of Toronto, 5 King's College Rd., Toronto, Canada, jcb@mie.utoronto.ca, Wen-Yang Ku

Inspired by the geometric reasoning exploited in discrete ellipsoid-based search (DEBS) from the communications literature, we develop a constraint programming (CP) approach to solve problems with convex quadratic constraints. Such constraints appear in numerous applications such as modelling the ground-to-satellite distance in GPS and evaluating the efficiency of a schedule with respect to quadratic objective functions. We strengthen the key aspects of the DEBS approach and implement them as combination of a global constraint and variable/value ordering heuristics. Preliminary experiments on a variety of benchmark instances show promising results.

2 - Combinatorial Optimization for Workload Dispatching on the EURORA Supercomputer

Michele Lombardi, DISI, University of Bologna, Viale del Risorgimento 2, Bologna, 40136, Italy, michele.lombardi2@unibo.it, Andrea Borghesi, Thomas Bridi, Michela Milano, Andrea Bartolini

We tackle the problem of job dispatching on a supercomputer with heterogeneous architecture. The problem consists in mapping and scheduling a stream of computation-intensive jobs with approximately known duration. Currently, this is done done via a rule-based system that incurs the risk of causing resource fragmentation (and hence underutilization) or large waiting times. We are working on an alternative approaches based on Constraint Programming and MILP. A prototype has already been realized and deployed both in a simulated environment and on the real supercomputer. The approach is leading to significant improvements in terms of waiting times and comparable machine utilization w.r.t. the dispatcher currently installed.

3 - Scheduling Scientific Experiment for Comet Exploration

Gilles Simonin, Senior PostDoctoral Researcher, Insight Centre for Data Analytics, University College Cork,, Western Road, Cork, Ireland, gilles.simonin@insight-centre.org, Emmanuel Hebrard, Christian Atigues, Pierre Lopez

The Rosetta/Philae mission was launched in 2004 by the European Space Agency. It was scheduled to reach a comet in 2014 and attempt the first ever landing on its surface. We describe a constraint programming model for scheduling the different experiments of the mission. A feasible plan must satisfy several constraints as energy, precedence, incompatibility and the transfer of all the data produced by the instruments. We introduce a global constraint to handle data transfers. The goal of this constraint is to ensure that data-producing tasks are scheduled in such a way that no data is lost. From our results, mission control was able to compute feasible plans in a few seconds for scenarios where minutes were previously often required.

■ MC26

26- Forbes Room

Progress in Financial Optimization

Cluster: Finance and Economics

Invited Session

Chair: Somayeh Moazeni, Assistant Professor, Stevens Institute of Technology, 1 Castle Point Terrace on Hudson, Hoboken, NJ, 07030, United States of America, smoazeni@stevens.edu

Co-Chair: Boris Defourny, Assistant Professor, Lehigh University, 200 W Packer Ave, Bethlehem, PA 18015, United States of America, defourny@lehigh.edu

1 - Genetic Programming Optimization for a Sentiment Feedback Strength-based Trading

Steve Yang, Assistant Professor, Stevens Institute of Technology, 1 Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, steve.yang@stevens.edu, Sheung Yin Mo

In this study we present a novel framework to developing a sentiment-based trading strategy using genetic programming. We propose a sentiment indicator based on feedback strength between the news and tweet sentiments, and we aim to solve the optimization problem to maximize risk-adjusted returns with the sentiment indicator. We find that the sentiment-based genetic programming approach yields consistent excessive market returns with small standard deviation over the two years from 2012 to 2014. Using the Stirling ratio and other risk measures, our study suggests that news and tweet sentiment can be regarded as valuable sources of information in constructing meaningful trading system along with technical indicators.

2 - Branch-and-Cut for Cardinality and Semi-Continuous Constrained Optimization

Ming Zhao, SAS, 100 SAS Campus, Cary, United States of America, ming.zhao@sas.com, Feng Qiu

Large asset management companies usually manage assets against given indices. The desired portfolio optimization problem involves using cardinality constraints to limit the number of securities in the portfolio and semi-continuous variables to enforce the minimal transaction levels. In this talk, we present cutting planes for these combinatorial constraints and show their efficacy in computational experiments.

3 - Data-Driven Dynamic Portfolio Execution

Somayeh Moazeni, Assistant Professor, Stevens Institute of Technology, 1 Castle Point Terrace on Hudson, Hoboken, NJ, 07030, United States of America, smoazeni@stevens.edu, Boris Defourny

We study the problem of portfolio trading in the presence of permanent and temporary price impacts to maximize the expected profit. We discuss and compare optimal trading strategies under different market price models and updating approaches.

■ MC27

27- Duquesne Room

Primal-Dual and Proximal Methods in Sparse Optimization I

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Stephen Becker, Assistant Professor, University of Colorado Boulder, 526 UCB, University of Colorado, Boulder, CO, 80309, United States of America, Stephen.Becker@colorado.edu

1 - An Inertial Forward-Backward Algorithm for Monotone Inclusions

Thomas Pock, Graz University of Technology, Inffeldgasse 16, Graz, 8010, Austria, pock@icg.tugraz.at, Dirk Lorenz

In this paper, we propose an inertial forward back-ward splitting algorithm to compute a zero of the sum of two monotone operators, with one of the two operators being co-coercive. The algorithm is inspired by the accelerated gradient method of Nesterov, but can be applied to a much larger class of problems including convex-concave saddle point problems and general monotone inclusions. We prove convergence of the algorithm in a Hilbert space setting and show that several recently proposed first-order methods can be obtained as special cases of the general algorithm. Numerical results show that the proposed algorithm converges faster than existing methods, while keeping the computational cost of each iteration basically unchanged.

2 - A Family of Friendly Proximals

Gabriel Goh, UC Davis, Davis, CA, United States of America, gabgohjh@gmail.com

We show how an interior method can be used to compute the proximal operator of a convex function under different metrics, where both the metric and the function have simultaneous structure that allow the proximal map to be computed in time nearly linear in the input size. We describe how to use this approach to implement quasi-Newton methods for a rich class of nonsmooth problems that include important signal-processing applications.

3 - Barrier Smoothing Methods for Non-Smooth Composite Convex Optimization

Quoc Tran-Dinh, Laboratory for Information and Inference Systems (LIONS), EPFL, Switzerland, EPFL STI IEL LIONS, ELD 243 (B,timent ELD) Station 11, Lausanne, 1015, Switzerland, quoc.trandinh@epfl.ch, Volkan Cevher

We study a smoothing framework using self-concordant barriers for non-smooth composite convex optimization. Self-concordant barriers have been widely used in interior-point methods but have not fully exploited in composite convex optimization settings. Our main idea is to use such functions for smoothing non-smooth convex problems, and to identify the advantages of this technique. Then, develop a class of optimization algorithms, including the first-order, second order and path-following methods, for solving non-smooth composite convex minimization problems with rigorous convergence guarantees.

■ MC28

28- Liberty Room

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Matthias Koeppe, Professor, UC Davis, 1 Shields Ave, Davis, CA, 95616, United States of America, mkoeppe@math.ucdavis.edu

1 - Boolean p-Power and p-Cut Polytopes

Miriam Schloeter, Institute of Mathematics - TU Berlin, Strasse des 17. Juni 136, MA 520, Berlin, 10587, Germany, schloeter@math.tu-berlin.de, Guenter M. Ziegler

In this talk we look at generalizations of the correlation polytope and the cut-polytope. We investigate some properties of these polytopes and mainly look at their symmetry groups. In 2013 Maksimenko introduced the boolean p-power polytope BQP(n,p), a generalization of the correlation polytope. We define the p-cut polytope CUT(n,p) which generalizes the cut-polytope and shares its symmetries - it is symmetric under switchings and permutations of coordinates. Also, we show that BQP(n,p) is linearly isomorphic to CUT(n+p-1,p) via a generalization of the covariance map. Further, we derive the Euclidean symmetry groups of CUT(n,p) and BQP(n,p), present some calculations regarding their affine symmetry group and derive it for special cases.

2 - Extreme Functions for the Gomory-Johnson Infinite Group Problem

Yuan Zhou, UC Davis, 1 Shields Ave, Davis, CA, 95616, United States of America, yzh@math.ucdavis.edu, Matthias Koeppe

Extreme functions for the Gomory-Johnson infinite group problem serve as strong cut-generating functions for general integer linear programs. For the single-row infinite group problem, our recent work on computer based search discovers piecewise linear extreme functions with up to 28 slopes, breaking the previous record of 5 slopes due to Hildebrand (2013). Several open questions are resolved by some other newly discovered extreme functions. We discuss various search approaches, their computational performance and limits.

3 - Light on the Infinite Group Relaxation

Matthias Koeppe, Professor, UC Davis, 1 Shields Ave., Davis, CA, 95616, United States of America, mkoeppe@math.ucdavis.edu, Yuan Zhou, Amitabh Basu, Robert Hildebrand

The infinite group problem was introduced 42 years ago by Gomory and Johnson in their famous papers titled "Some continuous functions related to corner polyhedra I, II". We now recognize this approach as one that was decades ahead of its time and may be the key to today's pressing need for stronger, multi-row cutting planes. I will survey the recent progress on the problem, present software, and highlight open questions.

■ MC29

29- Commonwealth 1

Splitting Methods and Applications

Cluster: Nonsmooth Optimization

Invited Session

Chair: Wotao Yin, Professor, University of California, Los Angeles, Box 951555, 520 Portola Plz, MS 7620B, Los Angeles, CA, 90095, United States of America, wotaoyin@math.ucla.edu

1 - Self Equivalence of the Alternating Direction Method of Multipliers

Ming Yan, Assistant Adjunct Professor, University of California, Los Angeles, Los Angeles, CA, 90095, United States of America, yanm@math.ucla.edu, Wotao Yin

In this talk, we show many of the seemingly different ways of applying ADM are equivalent. Specifically, we show that ADM applied to a primal formulation is equivalent to ADM applied to its Lagrange dual; ADM is equivalent to a primal-dual algorithm applied to the saddle-point formulation of the same problem. These results are surprising since some previous work exhibits strong preferences in one over the other on specific problems. In addition, when one of the two objective functions is quadratic, we show that swapping the update order of the two primal variables in ADM gives the same algorithm. These results identify the few truly different ADM algorithms for a problem, which generally have different forms of subproblems.

2 - A Three Operator Splitting Scheme and its Optimization Applications

Damek Davis, University of California, Los Angeles, Box 951555, Los Angeles, United States of America, damek@math.ucla.edu, Wotao Yin

For over 50 years, operator-splitting schemes have been used to solve PDE, feasibility problems, and more recently, large-scale problems in data analysis. Despite much development, it is known that all existing splitting schemes reduce to one of three basic schemes, each introduced between 15 and 36 years ago. In this talk, we introduce a new splitting scheme that extends the Douglas-Rachford and forward-backward splitting schemes to monotone inclusions with three operators, one of which is cocoercive. We discuss why this algorithm works, derive the currently simplest three-block and proximal ADMMs, and introduce two accelerations that achieve optimal rates for strongly monotone inclusions. Finally, we discuss several applications.

3 - Total Variation Image Deblurring with Space-varying Kernel via Douglas-Rachford Splitting

Daniel O'Connor, University of California, Los Angeles, 530 Glenrock Ave, #29, Los Angeles, CA, 90024, United States of America, daniel.v.oconnor@gmail.com, Lieven Vandenberghe

Most existing methods for total variation image deblurring use the L2-TV formulation and assume the blur kernel is spatially invariant. In this talk, we show that TV deblurring algorithms based on the Douglas-Rachford splitting method are able to handle non-quadratic data fidelity terms, general (non-periodic) boundary conditions, constraints, and also spatially variant blur kernels described by the Nagy-O'Leary and Efficient Filter Flow models. Moreover, these algorithms can be implemented with a low complexity per iteration, dominated by a small number of fast Fourier transforms. Thus, though these algorithms solve a much more general problem, they achieve a complexity that is comparable to that of standard L2-TV methods.

■ MC30

30- Commonwealth 2

Approximation and Online Algorithms II

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Samir Khuller, Professor and Chair, U. Maryland, AV Williams Bldg, College Park, MD, 20742, United States of America, samir@cs.umd.edu

1 - Scheduling with State-Dependent Machine Speeds

Veerle Timmermans, Maastricht University, Tongersestraat 53, Maastricht, Ne, 6211 LM, Netherlands, v.timmermans@maastrichtuniversity.nl, Tjark Vredeveld

We study a preemptive single machine scheduling problem where the machine speed is externally given and depends on the number of unfinished jobs. The objective is to minimize the sum of weighted completion times. We introduce a greedy algorithm that solves the problem to optimality when we work with either unit weights or unit processing times. If both weights and processing times are arbitrary, we show the problem is NP-hard by making a reduction from 3-partition.

2 - A Logarithmic Approximation for Matroid Congestion Models

Tim Oosterwijk, Maastricht University, Department of Quantitative Economics, Maastricht University, P.O. Box 616, Maastricht, Netherlands, t.oosterwijk@maastrichtuniversity.nl, Tjark Vredeveld, Tobias Harks

We study the problem of computing a social optimum in matroid congestion games, where the strategy space of every player consists of the set of bases of a player-specific matroid defined on the ground set of resources. We devise and analyse an approximation algorithm. The main idea of our algorithm is to iteratively increase resource utilization in a greedy fashion and to invoke a covering oracle that checks feasibility of every computed resource utilization.

3 - Busy and Active Time Scheduling

Samir Khuller, Professor and Chair, U. Maryland, AV Williams Bldg, College Park, MD, 20742, United States of America, samir@cs.umd.edu, Jessica Chang, Koyel Mukherjee

Traditional scheduling algorithms, especially those involving job scheduling on parallel machines, make the assumption that the machines are always available and try to schedule jobs to minimize specific job related metrics. Since modern data centers consume massive amounts of energy, we consider job scheduling problems that take energy consumption into account, turning machines off, especially during periods of low demand. The ensuing problems relate very closely to classical covering problems such as capacitated set cover, and we discuss several recent results in this regard. In summary, we study several batch scheduling problems under different constraints, taking energy cost into account.

Monday, 2:45pm - 4:15pm

■ MD01

01- Grand 1

Advances in Penalization Methods for Linear and Nonlinear Programming

Cluster: Variational Analysis

Invited Session

Chair: Roger Behling, Professor, Federal University of Santa Catarina, Campus Blumenau, Blumenau, SC, 89065-300, Brazil, rogerbehling@gmail.com

1 - Penalizing Simple Constraints on Augmented Lagrangian Methods

Luis Felipe Bueno, Professor, Federal University of São Paulo, Campus São José dos Campos, São José dos Campos, SP, 12230240, Brazil, lfelipebueno@gmail.com, José Mario Martìnez, Ernesto G. Birgin

In this work an Augmented Lagrangian approach will be presented to solve optimization problems where simple constraints will be penalized. Our proposal is innovative because it breaks a usual paradigm which is to maintain the feasibility with respect to these constraints in this kind of methods. We will discuss the possibility of using this approach against active set methods and, mainly, against interior point methods. We will highlight the algebraic and geometric advantages involved in this approach. We will also present some relations with Inexact Restoration methods and Proximal methods for linear and nonlinear programming.

2 - Convergence Analysis of an Infeasible Interior-Point Method with Optimized Choice of Parameters

Luiz-Rafael Santos, Professor, Federal University of Santa Catarina, Campus Blumenau, Blumenau, SC, 89065-300, Brazil, lrsantos11@gmail.com, Fernando Villas-Boas, Aurelio Oliveira, Clovis Perin

In this work, we propose a predictor-corrector interior-point method for linear programming, where the next iterate is chosen by the minimization of a polynomial merit function on three variables: one is the step length, one defines the central path and the last one models the weight that a corrector direction must have. In this framework, we combine different directions with the aim of producing a better one. The proposed method generalizes most of predictor-corrector interior-point methods, depending on the choice of the variables described above. Convergence analysis and numerical experiments of the method are carried out, which show that this approach is competitive when compared to well established solvers, such as PCx.

3 - The Effect of Calmness on the Solution Set of Systems of Nonlinear Equations

Roger Behling, Professor, Federal University of Santa Catarina, Campus Blumenau, Blumenau, SC, 89065-300, Brazil, rogerbehling@gmail.com, Alfredo Iusem

We address the problem of solving a continuously differentiable nonlinear system of equations under the condition of calmness. This property is known to be significantly weaker than classic regularity assumptions that imply that solutions are isolated. We prove that under this condition, the rank of the Jacobian of the function that defines the system of equations must be locally constant on the solution set. In addition, we prove that locally, the solution set must be a differentiable manifold. Our results are illustrated by examples and discussed in terms of their theoretical relevance and algorithmic implications.

■ MD02

02- Grand 2

Complementarity Modelling in the Energy Sector

Cluster: Optimization in Energy Systems

Invited Session

Chair: Afzal Siddiqui, University College London, Department of Statistical Science, Gower Street, London, WC1E 6BT, United Kingdom, afzal.siddiqui@ucl.ac.uk

1 - Benders' Decomposition for Strategic Bidding Modeling in Wind-Integrated Power Systems

Ekaterina Moiseeva, PhD Student, KTH Royal Institute of Technology, Teknikringen 33, Stockholm, 10044, Sweden, moiseeva@kth.se, Mohammad Reza Hesamzadeh

The need for fast-ramping generators is especially high in wind-integrated systems. If we consider the uncertainty the problem of a profit-maximizing power company able to withhold the ramp-rate takes a form of a stochastic MPEC, which we recast as a MILP. We accelerate the convergence by applying the Benders' decomposition preceded by a bounding phase based on Jensen's inequality, and solving the linear subproblems in parallel.

2 - Endogenizing Long-Term Contracts in Gas Market Models

Yves Smeers, Professor, Université Catholique de Louvain, CORE, Voie du Roman Pays, 34, Louvain-la-Neuve, 1348, Belgium, yvessmeers@me.com, Ibrahim Abada, Andreas Ehrenmann

We present a stochastic equilibrium model that endogenously captures the contracting behavior of both the producer and the mid-streamer who strive to hedge their profit related risk and can select among contracts indexed on oil and spot gas prices. We test the impact of correlation between oil and spot gas prices and of the structure of upstream cost.

3 - How Much is Enough? Optimal Capacity Payments in a Renewable-Rich Power System

Afzal Siddiqui, University College London, Department of Statistical Science, Gower Street, London, WC1E 6BT, United Kingdom, afzal.siddiqui@ucl.ac.uk, Tuomas Rintam aeki, Ahti Salo

In Germany, the deployment of intermittent renewable energy sources has increased the need for offsetting flexible capacity. The uneven geographical distribution of wind power is causing congestion in the transmission grid, which creates a need for fast-adjusting balancing capacity. Recently, capacity payments to flexible plants have been proposed by the government to mitigate energy imbalances. We take the perspective of the regulator via a bi-level programming model to study the impacts of capacity payments and to determine their optimal level. Our results suggest that although such payments do not necessarily lower system costs, they, nevertheless, alleviate congestion and may be used as part of policy to integrate renewable energy.

■ MD03

03- Grand 3

Submodularity in Machine Learning – Theory and Practice

Cluster: Combinatorial Optimization

Invited Session

Chair: Stefanie Jegelka, Assistant Professor, MIT, Stata Center, Cambridge, MA, 02139, United States of America, stefje@mit.edu

1 - Linear Programming and Valued Constraint Satisfaction Problems

Vladimir Kolmogorov, Professor, IST Austria, Am Campus 1, Klosterneuburg, Austria, vnk@ist.ac.at

I will consider the Valued Constraint Satisfaction Problem (VCSP), whose goal is to minimize a sum of local terms where each term comes from a fixed set of functions (called a "language") over a fixed discrete domain. I will present recent results characterizing languages that can be solved using the basic LP relaxation. This includes languages consisting of submodular functions, as well as their generalizations. Based on joint papers with Andrei Krokhin, Michal Rolinek, Johan Thapper and Stanislav Zivny.

2 - Submodular Labeling Problems in Image Segmentation

Jan Vondrak, IBM Almaden Research Center, 650 Harry Rd, San Jose, CA, 95120, United States of America, jvondrak@gmail.com

We will discuss labeling/partitioning problems that arise in image segmentation. An example of such a problem is uniform metric labeling. More generally, submodular cost functions arise naturally in this context. I will describe algorithms with optimal approximation factors (assuming the UGC) for several variants of such problems.

3 - Submodular Semidifferentials: Polyhedra, Algorithms and Applications

Rishabh Iyer, PhD Student, University of Washington, Department of Electrical Engg, Seattle, WA, 98195, United States of America, rkiyer@u.washington.edu, Jeff Bilmes

In this work, we investigate submodular semidifferentials from a polyhedral and algorithmic point of view. In particular, we show the existence of the superdifferentials and tight modular upper bounds of a submodular function, and contrast this with existing results on the subdifferential of a submodular functions. We then discuss several applications of these semidifferentials (i.e sub and super differentials), including a majorization-minimization framework of algorithms for several classes of submodular optimization problems. Finally, we show connections between optimality conditions over the superdifferentials and submodular maximization, and contrast them to existing results connecting subdifferentials and submodular minimization.

■ MD04

04- Grand 4

Linear Algebra Techniques in Conic Optimization

Cluster: Conic Programming

Invited Session

Chair: Jacek Gondzio, Professor, University of Edinburgh, King's Buildings, Edinburgh, Edinburgh, EH9 3FD, United Kingdom, J.Gondzio@ed.ac.uk

1 - On the Linear Algebra Employed in the MOSEK Conic Optimizer

Erling Andersen, CEO, MOSEK ApS, Fruebjergvej 3, Copenhagen, 2100, Denmark, e.d.andersen@mosek.com

MOSEK implements a high performance interior-point based optimizer for linear, conic quadratic and semidefinite optimization problems. In this talk we will discuss the linear algebra techniques employed in the interior-point optimizer to achieve good performance. In particular we will discuss how we have addressed the many core challenge i.e. how to exploit all the cores modern CPUs have.

2 - A New Approach for Solving Large Sparse Semidefinite Programming Problems with Interior Point Methods

Stefania Bellavia, Universita degli Studi di Firenze, stefania.bellavia@unifi.it, Margherita Porcelli, Jacek Gondzio

Interior point methods for Semidefinite Programming (SDP) face a difficult linear algebra subproblem. We propose an algorithm which allows for an iterative scheme to solve the Newton equation system arising in SDP. It relies on a new preconditioner which exploits well the sparsity of matrices. Theoretical insights into the method will be provided. Computational results will be reported.

3 - Stability of Preconditioned Solvers in Inexact Interior-point Methods

Benedetta Morini, Universita di Firenze, viale G.B. Morgagni 40, Firenze, Italy, benedetta.morini@unifi.it, Valeria Simoncini

Primal-dual interior point (IP) methods for large convex quadratic programming require the solution of a linear system at each iteration, to compute the next step. We consider symmetric indefinite formulations for this system and iterative solvers for its approximate solution. We discuss some issues arising in this linear algebra phase including: conditioning of the preconditioned problem, IP-driven stopping criteria for the solver, and accuracy of the inexact step taking into account finite precision arithmetic.

■ MD05

05- Kings Garden 1

Nonconvex Optimization and Eigenvalues

Cluster: Nonlinear Programming

Invited Session

Chair: Yuji Nakatsukasa, University of Tokyo, Deptartmeht of Mathematical Informatics, Tokyo, 113-8656, Japan, nakatsukasa@mist.i.u-tokyo.ac.jp

1 - Solving the Trust Region Subproblem by a Generalized Eigenvalue Problem

Yuji Nakatsukasa, University of Tokyo, Deptartment of Mathematical Informatics, Tokyo, 113-8656, Japan, nakatsukasa@mist.i.u-tokyo.ac.jp, Satoru Iwata, Satoru Adachi, Akiko Takeda

The trust region subproblem is usually solved via an iterative process. An alternative approach is semidefinite programming, but this also involves solving linear systems iteratively. This work introduces an algorithm that requires just one eigenpair of a generalized eigenvalue problem. Our algorithm deals with the so-called hard case, directly allows for non-standard norms without changing variables, and is suited both to dense and large-sparse problems. We demonstrate its accuracy and efficiency through experiments.

2 - A Polynomial-Time Algorithm for Nonconvex Quadratic Optimization with Two Quadratic Constraints

Shinsaku Sakaue, University of Tokyo, Dept. Mathematical Informatics, University of Tokyo, Tokyo, 113-8656, Japan, shinsaku_sakaue@mist.i.u-tokyo.ac.jp, Yuji Nakatsukasa, Akiko Takeda, Satoru Iwata

We consider nonconvex quadratic optimization with two quadratic constraints (2QCQP), which includes the Celis-Denis-Tapia (CDT) problem. Until Bienstock's recent work, no polynomial-time algorithm was known for CDT. His algorithm solves CDT by admitting small errors in constraints. However, its implementation seems not straightforward. In this presentation, we propose a polynomial-time algorithm to solve 2QCQP exactly. Our algorithm computes all Lagrange multipliers via eigenvalue computation, obtains all KKT points, and finds a global solution among them.

3 - Global Convergence of the Higher-Order Power Method for Tensors via Lojasiewicz Inequality

André Uschmajew, University of Bonn, Wegelerstr. 6, 53115 Bonn, Germany, uschmajew@ins.uni-bonn.de

The higher-order power method for calculating the largest singular value of the multilinear form associated to a tensor under spherical constraints generalizes the matrix power method. It is equivalent to the alternating least-squares algorithm for best rank-one approximation. The question of global convergence (to some critical point of the multilinear form) of this algorithm has been an open problem, and was only recently established for almost every tensor by Wang and Chu. By making use of nontrivial, but well-known results on point-wise convergence of discrete gradient flows in the presence of Lojasiewicz gradient inequality, we can give an alternative, more direct proof of convergence that applies to every tensor.

■ MD06

06- Kings Garden 2

Incremental Network Design

Cluster: Telecommunications and Networks

Invited Session

Chair: Dmytro Matsypura, The University of Sydney, Rm 478 Merewether Building H04, Sydney, Australia, dmytro.matsypura@sydney.edu.au

1 - A Robust Optimisation Approach to Bushfire Fuel Management

Dmytro Matsypura, The University of Sydney, Rm 478 Merewether Building H04, Sydney, Australia, dmytro.matsypura@sydney.edu.au, Oleg Prokopyev

Bushfires represent a real and continuing problem that can have a major impact on people, wildlife and the environment. One way to reduce the severity of their effect is through fuel management, which usually consists of mechanical thinning and prescribed burning of the landscape. We propose a general methodology to address the problem of optimal resource allocation for bushfire fuel management subject to landscape connectivity and stochastic fuel regeneration. We develop a number of mixed integer programming formulations that are based on various landscape connectivity metrics and present extensive computational experiments that reveal interesting insights and demonstrate advantages and limitations of the proposed framework.

2 - On Incremental Network Design Under Uncertainty

Pavlo Krokhmal, University of Iowa, 2136 Seamans Center, Iowa City, IA, 52242, United States of America, krokhmal@engineering.uiowa.edu, Nathaniel Richmond

We consider the incremental network design problem, where the goal is to improve an existing network by building new arcs, given that only one arc can be built at a time, the arc budget is limited, and at each time step the desired network characteristic (e.g., a shortest path between two nodes) is minimized. Previous studies have shown this problem to be NP-hard. A stochastic extension of the problem is presented, and the theoretical and computational properties of its solutions are discussed.

3 - Network Flows with Blending Constraints: Application to Lithium Mining

Paul Bosch, Universidad del Desarrollo, Ave. Plaza 680, Las Condes, Santiago, Chile, pbosch@udd.cl

We present a blending model of chemical solutions over a network of interconnected pipes and pumps. The main objective of the model is to achieve quality requirements on the network's output. The traditional way of modelling this problem considers flow and quality variables, under the new proposed model the focus is on feasibility, the problem is transformed into a non-convex network flow problem. The model has been numerically implemented and tested, the results confirm the adequacy of the modelling approach to provide solutions to the problem.

■ MD07

07- Kings Garden 3

Data Sparsity in Optimization

Cluster: Sparse Optimization and Applications

Invited Session

Chair: John Duchi, Stanford University, Sequoia Hall 126, 390 Serra Mall, Stanford, CA, 94305, United States of America, jduchi@stanford.edu

1 - Measure Twice, Cut Once: Measuring Sparsity to Improve Computation

Christopher Re, Professor, Stanford University, Computer Science Department, Stanford, CA, 94305, United States of America, chrismre@cs.stanford.edu

Sparsity can be a challenge statistically and computationally, but it can also be an opportunity. This talk will describe two ways in which measuring sparsity led us to improve an algorithm's run-time. First, I'll describe asynchronous optimization algorithms in our Hogwild! and DimmWitted projects, whose central technical results revolve around different ways of measuring sparsity to provide for more rapidly converging algorithms. Second, I will describe a discrete case in which we used a kind of sparsity measure as a proxy for complexity. This led to unexpected geometric algorithms for classical problems such as finding motifs in graphs and problems in logic, which allow us to provide instance optimality runtime guarantees.

2 - Robustness, Long Tails, and Data Sparsity

John Duchi, Stanford University, Sequoia Hall 126, 390 Serra Mall, Stanford, CA, 94305, United States of America, jduchi@stanford.edu

We study stochastic optimization problems when data is sparse and long-tailed, which is in a sense dual to current perspectives on high-dimensional statistical learning and optimization. We highlight difficulties—in terms of slower convergence rates and increased sample complexity that sparse data necessitates—and potential benefits, in terms of allowing asynchrony in design of algorithms. We also consider robustness and adaptivity to sparsity, developing procedures that are robust to changes in the distribution generating problem data, showing optimization and estimation consequences thereof. We provide experimental evidence complementing our theoretical results on several medium to large-scale tasks.

3 - A General Framework for Fast Stagewise Algorithms

Ryan Tibshirani, Assistant Professor, Carnegie Mellon University, 229B Baker Hall, Pittsburgh, PA, 15213, United States of America, ryantibs@gmail.com

Forward stagewise regression has an intriguing connection to the lasso. Under some conditions, it can be shown that the sequence of forward stagewise estimates exactly coincides with the lasso path, as the stagewise step size goes to zero. Even when they do not match their l1-regularized analogues, stagewise estimates are statistically useful and computationally appealing. This motivates the question: can a simple, effective strategy like forward stagewise be applied more broadly in other regularization settings, beyond the l1 norm and sparsity? I present a general framework for stagewise estimation, which yields fast algorithms for problems such as group-structured learning, matrix completion, image denoising, and more.

■ MD08

08- Kings Garden 4

Bilevel Programming Problems in Combinatorial Optimization and Game Theory

Cluster: Combinatorial Optimization

Invited Session

Chair: Stefano Coniglio, PhD, RWTH Aachen University, Lehrstuhl 2 für Mathematik, Pontdriesch 14-16, Aachen, 52062, Germany, coniglio@math2.rwth-aachen.de

1 - Bilevel Optimization in Game Theory

Margarida Carvalho, INESC TEC and Faculty of Sciences, University of Porto, Rua Campo Alegre 1021/1055, Porto, 4169-007, Portugal, margarida.carvalho@dcc.fc.up.pt, Alberto Caprara, Gerhard Woeginger, Andrea Lodi

Real economic markets can be described as games, this is, a participant decision has influence in the other participants' revenues. In this presentation, an algorithmic method for a sequential game, the bilevel knapsack with interdiction constraints, is proposed and it's generalization to other competitive games is discussed. We conclude by showing that a broad class of simultaneous mixed integer games is at least as hard as this bilevel knapsack problem.

2 - A Backward Sampling Framework for Interdiction Problems with Fortification

Leonardo Lozano, PhD Student, Clemson University, llozano@clemson.edu, Cole Smith

We examine a class of three-stage sequential defender-attacker-defender problems that are notoriously difficult to optimize, and almost always require the third-stage (recourse) problem to be a convex optimization problem. We propose a new approach in which we allow the recourse problem to take any form. The proposed framework restricts the defender to select a recourse decision from a sample of feasible vectors and iteratively refines the sample to force finite convergence to an optimal solution. We provide computational experiments on the traveling salesman interdiction problem with fortification to demonstrate that our algorithm solves interdiction problems involving NP-hard recourse problems within reasonable computational limits.

3 - Novel Formulations for General Stackelberg and Stackelberg Security Games

Carlos Casorran-Amilburu, PhD Candidate, Université Libre de Bruxelles, Boulevard du Triomphe B-1050 Bruxelles, Brussels, 1050, Belgium, casorranamilburu@gmail.com, Martine Labbé, Fernando Ordóñez, Bernard Fortz

We categorize Stackelberg Game formulations present in the literature, according to their use of big M constants and explore how they can be ordered in terms of tightness of their continuous relaxation. We present a novel formulation whose constraints do not require large positive constants. We provide tight values for these big M constants in each of the formulations and perform exhaustive computational experiments between formulations to see where we stand. We establish a relationship between the novel formulations provided for the General Stackelberg Games and for Security Games by means of a projection result and obtain convex hull-defining formulations when we restrict the problem to a single type of follower.

■ MD09

09- Kings Garden 5

Optimization under Uncertainty I

Cluster: Combinatorial Optimization

Invited Session

Chair: Nicole Megow, Technische Universitaet Berlin, Strasse des 17. Juni 136, Berlin, 10623, Germany, nmegow@math.tu-berlin.de

1 - A Randomized Algorithm for MST with Uncertainties

Julie Meissner, TU Berlin, Strasse des 17. Juni 136, Berlin, 10623, Germany, jmeiss@math.tu-berlin.de, Nicole Megow, Martin Skutella

We study a network design model where uncertain data is given in the form of intervals and exact data can be explored at a certain cost. The goal is to find the optimal network minimizing the exploration cost. For the minimum spanning tree problem with uncertainties we present the first randomized algorithm that beats the deterministic lower bound of 2. We achieve a competitive ratio of roughly 1.707 in expectation.

2 - On the Adaptivity Gap of Stochastic Orienteering

Viswanath Nagarajan, University of Michigan, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, viswa@umich.edu, Nikhil Bansal

The orienteering problem is a basic vehicle routing problem that has many applications. The input consists of a set of locations with associated rewards, distance bound B and a designated depot. In the stochastic orienteering problem, each location also has a random processing time which is realized only when that location is visited. The objective here is to find a non-anticipatory policy to visit locations that maximizes the expected reward subject to the total distance plus processing time being at most B. We focus on a natural special class of "non-adaptive" policies that are just specified by a permutation of the locations, and obtain results on how well such policies approximate the optimal adaptive policy.

3 - Stochastic Scheduling on Unrelated Machines

Marc Uetz, University of Twente, P.O. Box 217, Enschede, 7500AE, Netherlands, m.uetz@utwente.nl, Martin Skutella, Maxim Sviridenko

In this talk we study for the first time a scheduling problem that combines the classical unrelated machine scheduling model with stochastic processing times of jobs. By means of a novel time indexed linear programming relaxation, we compute in polynomial time a scheduling policy with performance guarantee (3+D)/2. Here, D is an upper bound on the squared coefficient of variation of the processing times. When jobs also have individual release dates, our bound is 2+D. We also show that the dependence of the performance guarantees on D is tight. Specifically, via D=0 the currently best known bounds for deterministic scheduling on unrelated machines are contained as special case.

■ MD10

10- Kings Terrace

Supply Chains

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Arindum Mukhopadhyay, Assistant Professor, IIM Shillong, Nongthymmai, Meghalaya, Shillong, 793014, India, arindum.iitkgp@gmail.com

1 - NLP and Derivative-Free Methods for Multi-Echelon Inventory Optimization: An Industrial Perspective

Anshul Agarwal, Associate Research Scientist, The Dow Chemical Company, 2301 Brazosport Blvd, B1603/1107, Freeport, TX, 77541, United States of America, AAgarwal2@dow.com, John M. Wassick

We present a nonlinear programming model for multi-echelon inventory optimization that captures reorder point undershoot and uses stochastic service time approach for lead time delay. Based on NLP results, we demonstrate how traditional mathematical programming approaches underestimate optimal inventory. We present a novel derivative-free simulation-optimization algorithm that uses sample average approximation, quantifies uncertainty by bootstrapping historical data, is computationally fast, captures non-standard inventory policies and constraints, and performs service level optimization. Industrial examples are presented.

2 - The Newsvendor Problem with Price-Dependent, Isoelastic Demand: Optimality and Risk Considerations

Javier Rubio-Herrero, Rutgers University, 100 Rockafeller Rd, Piscataway, NJ, 08854, United States of America, javier.rubioherrero@rutgers.edu, Melike Baykal-Gürsoy

We introduce the single-stage newsvendor problem with price-dependent, multiplicative, isoelastic demand. The goal of this study is to analyze the optimality of this problem when there are two decision variables, price and order quantity, and different risk considerations, namely risk-averse and risk-seeking individuals. We perform this work under the light of a mean-variance analysis and compare our results to others previously published using different measures of risk.

■ MD11

11- Brigade

Combinatorial Optimization under Uncertainty

Cluster: Combinatorial Optimization

Invited Session

Chair: Arie M.C.A. Koster, Professor, RWTH Aachen University, Lehrstuhl II für Mathematik, Aachen, 52056, Germany, koster@math2.rwth-aachen.de

1 - Dynamic Shortest-Path Interdiction

Cole Smith, Clemson University, jcsmith@clemson.edu, Jorge Sefair

We study a dynamic network game between an attacker and a user. The user wishes to traverse a shortest path, and the attacker seeks to interdict arcs to maximize the user's shortest-path cost. The attacker can interdict arcs any time the user reaches a node, and the user can respond by dynamically altering its chosen path. The challenge is to find an optimal path, coupled with the attacker's optimal interdiction strategy. We provide an exponential-state dynamic-programming algorithm, which can be reduced to a polynomial-time algorithm in the case of acyclic networks. We then develop bounds for the problem based on 2-stage interdiction and robust optimization models, or based on an exact solution to variations of this problem.

2 - Robust Maximum Flows over Time

Andreas Wierz, RWTH Aachen University, Kackertstrafle 7, Aachen, 52064, Germany, andreas.wierz@oms.rwth-aachen.de, Arie M.C.A. Koster, Frauke Liers, Britta Peis, Daniel Schmand, Corinna Gottschalk

We combine the fascinating world of robust optimization problems with the well-studied topic of maximum flows over time. Maximum flows over time seek to maximize the total throughput of a network within a given time horizon while flow requires a certain travel time in order to traverse each of the network's arcs. We investigate this problem in the presence of uncertain travel times under algorithmic and complexity theoretical aspects. A nominal travel time and a delay is known for each arc. Each arc assumes either its nominal or its delayed travel time and we assume that only a bounded number of edges may be disturbed simultaneously. Solutions have to satisfy ordinary flow constraints and the worst-case flow value is sought to be maximized.

3 - The Firefighter-Problem with Multiple Fires – On the Survival Rate of Trees

Nils Spiekermann, Lehrstuhl II für Mathematik RWTH Aachen University, Pontdriesch 14-16, Aachen, D-52062, Germany, spiekermann@math2.rwth-aachen.de, Eberhard Triesch

This talk deals with the firefighter problem, a game of bounding fire outbreaks on the vertices of a graph. Aim is to maximize the surviving-rate, the percentage of the vertices that can be protected on average if fires break out randomly. We extend the asymptotic constant lower bound by Cai and Wang (SIAM J. Discrete Math., 2009) for the case with one fire and one firefighter on trees, to an abritrary number of fires.

■ MD12 2:45pm - 3:25pm

12- Black Diamond

Do Analytics LLC - OPTEX Mathematical Modeling System: The Meta-Framework for Mathematical Programming

Cluster: Software Presentations

Invited Session

Chair: Jesús Velasquez, Mathematical Programming Entrepreneur - CEO and Chief Scientist, DecisionWare International Corp., Finca la Antigua, Tabio, Bogotá, Cu, Colombia, jesus.velasquez@decisionware.net

1 - Do Analytics LLC - OPTEX Mathematical Modeling System: The Meta-Framework for Mathematical Programming

Jes˙s Velasquez, Mathematical Programming Entrepreneur - CEO and Chief Scientist, DecisionWare International Corp., Finca la Antigua, Tabio, Bogota, Cu, Colombia, jesus.velasquez@decisionware.net

From 2015, the way how you make Optimization projects is going to be changed. A new company, a new technology, and a new methodology to implement real large scale mathematical programming models. Do Analytics presents OPTEX, a powerful meta-platform that: * Generates programming codes in the most powerful optimization technologies, including the SQL statements to connect any DBMS. * Mixes the power of an optimization technology with the easiness of EXCEL. * Works as a client and as an optimization server in the cloud. Easy and Fast, OPTEX represents the new generation to Do Analytics.

■ MD13

13- Rivers

Conic Programming for Low-Rank Matrix Recovery: Recent Advances in Convergence Rate Analysis and Recovery Guarantees

Cluster: Conic Programming

Invited Session

Chair: Anthony Man-Cho So, The Chinese University of Hong Kong, Dept of Sys Engg & Eng Mgmt, Shatin, NT, Hong Kong - PRC, manchoso@se.cuhk.edu.hk

1 - Convex Optimization Learning of Faithful Euclidean Distance Matrices in Dimensionality Reduction

Chao Ding, Assistant professor, Chinese Academy of Sciences, No. 55, Zhong Guan Cun Dong Lu, Haidian District, Beijing, 100190, China, dingchao@amss.ac.cn, Hou-Duo Qi

In this talk, we propose a new convex optimization model of learning Faithful Euclidean distance representations from noisy partial distances observations. For the proposed convex model, we establish a non-asymptotic error bound for the random graph model with sub-Gaussian noise, and prove that our model produces a matrix estimator of high accuracy when the order of the uniform sample size is roughly the degree of freedom of a low-rank matrix up to a logarithmic factor. A fast inexact accelerated proximal gradient method is developed, and numerical experiments show the model can produce configurations of high quality on large data points that the popular SDP approaches such as MVU and MVE would struggle to cope with.

2 - A Schatten p-Norm Perturbation Inequality and its Applications in Low-Rank Matrix Recovery

Man-Chung Yue, PhD, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, RM 2511, Man Tai House, Tsz Man Est.,, Tsz Wan Shan, KLN, Hong Kong, Hong Kong - PRC, mcyue@se.cuhk.edu.hk, Anthony Man-Cho So

In this paper, we prove a version of generalized Mirsky inequality, which answers an open question raised both in low-rank matrix recovery and linear algebra communities. As an application, we confirm the validity of a number of previously conjectured sufficient conditions for low-rank matrix recovery via the popular Schatten p-norm heuristic with $p<1$. This inequality also enables us to show that, for sufficiently small $p>0$, the number of samples needed for recovering a low-rank matrix using Schatten p-norm is less than that of using nuclear norm.

3 - On the Convergence Rate of the Proximal Gradient Method for Trace Norm Regularization

Zirui Zhou, The Chinese University of Hong Kong, ERB 511D, CUHK, Hong Kong, Hong Kong - PRC, zrzhou@se.cuhk.edu.hk, Anthony Man-Cho So

Motivated by various applications in machine learning, the problem of minimizing a convex smooth loss function with trace norm regularization has received much attention lately. Currently, a popular method for solving such problem is the proximal gradient method (PGM), which is known to have a sublinear rate of convergence. In this paper, we show that for a large class of loss functions, if strict complementarity condition is satisfied, the convergence rate of the PGM is in fact linear. Our result is established without any strong convexity assumption on the loss function. A key ingredient in our proof is a new Lipschitzian error bound for the aforementioned trace normñregularized problem, which may be of independent interest.

■ MD14

14- Traders

Games of Limited and Unlimited Rationality

Cluster: Game Theory

Invited Session

Chair: Nick Gravin, Microsoft Research, One Memorial Drive, Cambridge, Ma, 02142, United States of America, ngravin@gmail.com

1 - Economics of Repeated Sales

Balasubramanian Sivan, Microsoft Research, One Microsoft Way, Redmond, WA, 98052-6399, United States of America, balu2901@gmail.com, Nikhil R. Devanur, Yuval Peres

A special case of Myerson's (1981) classic work solves the revenue optimal mechanism design problem when a single seller sells a single item to a single buyer. In this talk, we consider a repeated version of this interaction: a seller offers to sell a single fresh copy of an item to the same buyer every day via a posted price. We compute the revenue in equilibrium when the seller is unable to commit to future prices, and also the setting when the seller is able to commit to not increase future prices upon purchase, but retains the right to lower future prices in the absence of a purchase. We highlight the striking difference in revenue between these two settings.

2 - Optimal Contracts for Revenue Extraction with Procrastinating Buyers

Emmanouil Pountourakis, PhD Candidate, Northwestern University, 2133 Sheridan Rd,, Ford Building, Ford 3-227, Evanston, IL, 60201, United States of America, manolis@u.northwestern.edu, Nicole Immorlica, Nick Gravin, Brendan Lucier

Motivated by time-inconsistent customers' behavior like in predatory money landing, and late payment fees for credit cards and utility bills we study contract design over an extended period of time for a procrastinating agent using a standard model from behavioral Economics. We assume that customer has a present bias, i.e., he overrates any immediate payment by a multiplicative factor, which is i.i.d random variable. We study structure and revenue of the optimal contract and how certain natural regulations on the contract space can affect maximal revenue.

3 - Level-0 Meta-Models for Predicting Human Behavior in Games

James Wright, PhD Candidate, University of British Columbia, 201-2366 Main Mall, Vancouver, BC, V6T 1Z4, Canada, jrwright@cs.ubc.ca, Kevin Leyton-Brown

Our own recent work has identified iterative models (e.g., quantal cognitive hierarchy) as the state of the art for predicting human play in unrepeated, simultaneous-move games. Iterative models predict that agents reason iteratively about their opponents, starting from a specification of nonstrategic behavior called level-0. In this work we replace the standard level-0 model (a uniform distribution over actions) with a ``meta-model" of how level-0 agents choose an action, given an arbitrary game, yielding substantial predictive improvements.

■ MD15

15- Chartiers

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: Jose Luis Morales, Professor, ITAM, Crepusculo 53 302, Mexico City, DF, 04530, Mexico, jmorales@itam.mx

1 - Compressibility of Positive Semidefinite Factorizations

Cyril Stark, MIT, 77 Massachusetts Ave, 6-304, Cambridge, MA, 02139, United States of America, cyril@mit.edu, Aram Harrow

We investigate compressibility of the dimension of positive semidefinite matrices while approximately preserving their pairwise inner products. This can either be regarded as compression of positive semidefinite factorizations of nonnegative matrices or (if the matrices are subject to additional normalization constraints) as compression of quantum models. We derive both lower and upper bounds on compressibility. Applications are broad and range from the analysis of robustness of positive semidefinite rank to bounding the one-way quantum communication complexity of Boolean functions. (Related preprint available under arXiv:1412.7437).

2 - On the Design and Implementation of SQP Methods

Jose Luis Morales, Professor, ITAM, Crepusculo 53 302, Mexico City, DF, 04530, Mexico, jmorales@itam.mx

In this talk we will discuss different aspects related with the design and implementation of SQP methods. We will focus on methods able to solve problems in the large scale setting.

3 - Alternating Linearization for Structured Regularization Problems

Minh Pham, Research Associate, SAMSI / Duke University, 19 TW Alexander Dr., Durham, NC, 27707, United States of America, ptuanminh@gmail.com, Andrzej Ruszczynski

We adapt the alternating linearization method for proximal decomposition to structured regularization problems, in particular, to the generalized lasso problems. The method is related to two well-known operator splitting methods, the Douglas-Rachford and the Peaceman-Rachford method, but it has descent properties with respect to the objective function. The convergence mechanism is related to that of bundle methods of nonsmooth optimization.We also discuss implementation for very large problems, with the use of specialized algorithms and sparse data structures. Finally, we present numerical results for several examples, including a three-dimensional fused lasso problem, which illustrate the scalability, efficacy, and accuracy of the method.

■ MD16

16- Sterlings 1

News in High Performance MIP Software

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Thorsten Koch, Prof. Dr., ZIB / TU Berlin, Takustr. 7, Berlin, 14195, Germany, koch@zib.de

1 - Presolving in Mixed Integer Programming

Tobias Achterberg, Gurobi Optimization, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, achterberg@gurobi.com, Edward Rothberg, Zonghao Gu, Robert Bixby, Dieter Weninger

A critical component in the solution of mixed integer programs is a set of routines commonly referred to as presolve. Presolve can be viewed as a collection of preprocessing techniques that reduce the size of and, more importantly, improve the ``strength" of the given model formulation, that is, the degree to which the constraints of the formulation accurately describe the underlying polyhedron of integer-feasible solutions. In the Gurobi commercial mixed integer solver, the presolve functionality has been steadily enhanced over time. In this talk we give an overview of the techniques implemented in Gurobi and present detailed computational results to assess their impact on overall solver performance.

2 - Recent Enhancements of the FICO Xpress Optimizer

Michael Perregaard, Fair Isaac Europe Ltd, International Square, Birmingham, United Kingdom, michaelperregaard@fico.com

We will present what is new in the linear, mixed integer and non-linear programming solvers within the Xpress Optimization Suite. This includes new solution refinement techniques to return more accurate solutions for both linear and mixed integer linear programs, including a new strong dual sensitivity analysis. We will also cover performance related features, such as a new handling of extensive non-linear formulas.

3 - Recent Advances in the SCIP Optimization Suite for Solving Mixed Integer Programs

Gregor Hendel, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, hendel@zib.de

The SCIP Optimization Suite provides flexible tools for modeling and solving various optimization problems. It is build around the Constraint Integer Programming framework SCIP, one of the fastest solvers for Mixed Integer Programs available in source code. After a brief introduction of key concepts behind SCIP, we focus on recent advances for MIP in its latest release, among which are new branching concepts, techniques for reoptimization with varying cost functions, and multicriteria optimization.

■ MD17

17- Sterlings 2

Methods for Large Scale Composite Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Marianna De Santis, TU Dortmund, Vogelpothsweg 87, 44227, Dortmund, Germany, marianna.de.santis@math.tu-dortmund.de

Co-Chair: Kimon Fountoulakis, The University of Edinburgh, k.fountoulakis@sms.ed.ac.uk

1 - Performance of First- and Second-Order Methods for Huge Scale Optimization

Kimon Fountoulakis, The University of Edinburgh, k.fountoulakis@sms.ed.ac.uk, Jacek Gondzio

We study the performance of first- and second-order optimization methods for l1-regularized sparse least-squares problems as the conditioning and the dimensions of the problem increase up to one trillion. A rigorously defined generator is presented which allows control of the dimensions, the conditioning and the sparsity of the problem. The generator has very low memory requirements and scales well with the dimensions of the problem.

2 - A Fast Active-Set Block Coordinate Descent Algorithm for l1-regularized Problems

Francesco Rinaldi, Department of Mathematics University of Padua, via Trieste, 73, Padua, Italy, rinaldi@math.unipd.it, Marianna De Santis, Stefano Lucidi

The problem of finding sparse solutions to large-scale l1-regularized problems arises in several applications. In this talk, we propose an active-set block coordinate descent approach for l-1 regularized problems. We analyze the convergence properties of the proposed method, prove that its basic version converges with linear rate, and report some numerical results showing the effectiveness of the approach.

3 - Iterative Sketching for Fast Solution Approximation in Constrained Least-Squares Problems

Mert Pilanci, UC Berkeley, Berkeley, CA, Berkeley, United States of America, mert@eecs.berkeley.edu, Martin Wainwright

We study randomized sketching methods for approximately solving least-squares problem with a convex constraint. Our first main result provides a general lower bound on any randomized sketching method and as a consequence, the most widely used least-squares sketch is sub-optimal for solution approximation. We then present a new iterative method and show that it can be used to obtain approximations to the original least-squares problem using a projection dimension proportional to the statistical complexity of the least-squares minimizer, and a logarithmic number of iterations. We illustrate our theory with simulations for both unconstrained and constrained versions of least-squares, including L1-regularization and nuclear norm constraints.

■ MD18

18- Sterlings 3

Stochastic Mixed-Integer Programming

Cluster: Stochastic Optimization

Invited Session

Chair: Simge Kucukyavuz, Ohio State University, 1971 Neil Ave, 244 Baker Systems, Columbus, OH, 43210, United States of America, kucukyavuz.2@osu.edu

1 - An Adaptive Partition-Based Approach for Solving Two-Stage Stochastic Programs with Fixed Recourse

Yongjia Song, Virginia Commonwealth University, 1015 Floyd Ave, Richmond, VA, 23284, United States of America, ysong3@vcu.edu, James Luedtke

A partition-based formulation is a relaxation of the original stochastic program, and we study a finitely converging algorithm in which the partition is adaptively adjusted until it yields an optimal solution. A solution guided refinement strategy is developed to refine the partition by exploiting the relaxation solution obtained from a partition. We also show that for stochastic linear programs with simple recourse, there exists a small partition that yields an optimal solution, whose size is independent of the number of scenarios. Computational results show that the proposed approach is competitive with the state-of-art methods for stochastic linear programs.

2 - A New Lagrangian Approach for Weakly Coupled Stochastic Dynamic Programs

Jagdish Ramakrishnan, Research Associate, Wisconsin Institute for Discovery, University of Wisconsin, Madison, WI, 53715, United States of America, jagdish.ram@gmail.com, James Luedtke

Current approaches for solving multi-stage stochastic mixed-integer programs are limited in their ability to handle multiple sample paths per stage, due to an exponential growth in the number of sample paths. We consider a weakly coupled model, which is amenable to decomposition into small Markov Decision Problems via Lagrangian relaxation. We extend previous work on this approach by allowing the Lagrange multipliers to depend on the observation history. The approach will be illustrated numerically for the stochastic unit commitment problem.

3 - Mixed-Integer Rounding for Stochastic Integer Programming

Merve Bodur, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI, 53706, United States of America, mbodur@wisc.edu, James Luedtke

With stochastic integer programming as the motivating application, we investigate ways to use mixed-integer rounding (MIR) to obtain improved cuts within a Benders decomposition algorithm. We investigate different techniques for using MIR and conduct a computational study on a wide class of stochastic integer programming instances to understand their relative strengths. We find that the MIR enhancements significantly improve the bounds over those obtained from standard Benders cuts, even after cuts from a commercial solver are applied to the Benders formulation.

■ MD19

19- Ft. Pitt

Optimization of Non-Smooth and Complementarity-Based Systems with PDE–Constraints I

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Thomas Surowiec, Humboldt-Universitaet zu Berlin, surowiec@math.hu-berlin.de

1 - Risk-Averse Optimization with PDE Constraints

Drew Kouri, Sandia National Laboratory, P.O. Box 5800, MS 1320, Albuquerque, NM, 87185, United States of America, dpkouri@sandia.gov

In this talk, I will discuss the notion of risk aversion for optimization problems governed by PDEs with uncertain inputs. Often risk-averse quantities are not differentiable in the classic sense. To make such quantities amenable to derivative-based optimization algorithms and global quadrature approximation, I will present a theory for smooth risk measures through the risk quadrangle. Finally, I will discuss the dual formulation of coherent risk measures. Building on this dual formulation, I will provide a regularized min-max approximation. I will prove consistency of each smooth approximation and provide algorithmic details for the solution of the smoothed optimization problems. I will conclude with numerical results.

2 - Optimal Placement and Trajectories of Sensor Networks under Constraints

Carlos Rautenberg, Humboldt-Universitaet zu Berlin, carlos.rautenberg@math.hu-berlin.de

We consider the optimal estimation problem for the distribution of a quantity of interest that diffuses and is transported (or convected) by a velocity profile. Measurements are obtained with a sensor network that can be static or dynamic. We assume that stochastic perturbations are present, and numerous constraints affect the sensor network. The problem is formulated as a constrained optimization problem subject to a differential Riccati equation. New results concerning properties of the solution to the Riccati equation with respect to the sensor network location are presented. An algorithm for the approximation of optimal trajectories is introduced and several numerical tests are included.

3 - A Two-Stage Stochastic PDE-Constrained Optimization Model for Active Control of Composite Structures

Dmitry Chernikov, University of Iowa, 3131 Seamans Center, Iowa City, IA, 52242, United States of America, dmitry-chernikov@uiowa.edu, Olesya Zhupanska, Pavlo Krokhmal

We consider the problem of optimization of “smart”, or “multifunctional” mechanical structures under uncertainty. In particular, a PDE-constrained optimization model for vibration mitigation of a composite plate due to an impact load is presented. The model employs the physical phenomenon of field coupling in electrically conductive solids to control plate’s deflections using an applied electromagnetic field. To account for uncertainty in the impact load, a two-stage stochastic PDE-constrained programming problem is formulated. A solution method based on first-order black-box optimization is proposed, and a computational study is discussed.

■ MD20

20- Smithfield

Theory, Lower Bounds

Cluster: Nonsmooth Optimization

Invited Session

Chair: Martin Takac, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, United States of America, martin.taki@gmail.com

Co-Chair: Martin Jaggi, Universitaetsstr 6, Zürich, 8092, Switzerland, jaggi@inf.ethz.ch

1 - Smooth Strongly Convex Interpolation and Exact Worst-Case Performance of First-Order Methods

Adrien Taylor, Université Catholique de Louvain, Avenue Georges Lemaitre, 4, Louvain-la-neuve, Belgium, adrien.taylor@uclouvain.be, Francois Glineur, Julien Hendrickx

We show that the exact worst-case performance of fixed-step first-order methods for smooth (possibly strongly) convex functions can be obtained by solving convex programs. We apply our approach to different fixed-step first-order methods with several performance criteria, including objective function accuracy and residual gradient norm. We conjecture several numerically supported worst-case bounds on the performance of the gradient, fast gradient and optimized fixed-step methods, both in the smooth convex and the smooth strongly convex cases.

2 - Coordinate Descent for Certain Problems in Semidefinite Programming

Jakub Marecek, IBM Research – Ireland, IBM Technology Campus Damastown, B3 F14, Dublin, D7, Ireland, jakub.marecek@ie.ibm.com, Martin Takac, Wann-Jiun Ma

We present a coordinate-descent algorithm for a rank-constrained hierarchy of relaxations of semidefinite programming, using a closed-form step, and variants thereof. We present promising results both in theory and practical implementations, which exploit the structures present in relaxations polynomial optimisation, in general, and in power systems analysis, in particular [B Ghaddar, J Marecek, M Mevissen, IEEE Transactions on Power Systems, 2015].

3 - Composite Convex Minimization Involving Self-Concordant-Like Cost Functions

Yen-Huan Li, PhD Student, EPFL – LIONS Lab, EPFL-STI-IEL-LIONS, Station 11, Lausanne, 1015, Switzerland, yen-huan.li@epfl.ch, Volkan Cevher, Quoc Tran-Dinh

The self-concordant like property is a new structure of smooth convex functions. While self-concordant like functions appear in many applications, this concept has not been exploited in convex optimization theory. We develop a proximal variable metric framework for minimizing the sum of a self-concordant like function and a “simple” convex function, with analytic step-size selection procedures and rigorous convergence guarantees. Our basic proximal gradient algorithm has a better convergence behavior than accelerated first-order algorithms.

■ MD21

21-Birmingham

Recent Advances in Derivative-Free and Simulation-Based Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Anke Troeltzsch, German Aerospace Center (DLR), Linder Hˆhe, Cologne, Germany, Anke.Troeltzsch@dlr.de

1 - Trust-Region Methods without using Derivatives: Worst Case Complexity and the Non-Smooth Case

Rohollah Garmanjani, Universidade de Coimbra, nima@mat.uc.pt, Diogo Júdice, Luis Nunes Vicente

We start by analyzing the worst case complexity of general trust-region derivative-free methods for smooth functions. For the non-smooth case, we propose a smoothing approach, for which we prove global convergence and bound the worst case complexity effort. For the special case of non-smooth functions that result of the composition of smooth and non-smooth/convex components, we show how to improve the existing results of the literature and make them applicable to the general methodology.

2 - A Derivative-Free Trust-Funnel Method for Nonlinear Optimization Problems with General Constraints

Phillipe Sampaio, University of Namur, Rempart de la Vierge 8, Namur, 5000, Belgium, phillipe.sampaio@unamur.be, Philippe Toint

A trust-funnel method is proposed for solving nonlinear optimization problems with general nonlinear constraints. It extends the one presented by Gould and Toint (Math. Prog., 122(1):155-196, 2010), originally proposed for equality-constrained problems only, to problems with both equality and inequality constraints and where simple bounds are also considered. As the original one, it makes use of neither filter nor penalty functions. Finally, we exploit techniques for derivative-free optimization to obtain a final method that can also be used to solve problems without derivatives.

■ MD22

22- Heinz

New Convexification and Branching Techniques for Nonconvex Optimization

Cluster: Global Optimization

Invited Session

Chair: Amir Ali Ahmadi, Princeton University, a_a_a@princeton.edu

1 - Envelopes of Bilinear Functions over Polytopes with Application to Network Interdiction

Daniel Davarnia, University of Florida, 303 Weil Hall, Gainesville, FL, United States of America, d.davarnia@gmail.com, Jean-Philippe P Richard, Mohit Tawarmalani

We extend the convexification technique of Nguyen et. al. (2013) to obtain, in the space of their defining variables, a linear description of the convex hull of graphs of bilinear functions over the Cartesian product of a general polytope and a simplex. We apply this procedure to study various sets including those arising from unary expansions of integer variables in MIBP. For network interdiction, our procedure yields an improved set of linearization constraints for bilinear objective terms that is cognizant of paths and cycles in the network. This linearization provides a convex hull description of a suitable problem relaxation and can be shown computationally to lead to significant gap reductions over traditional McCormick linearization.

2 - Feasibility-oriented Branching Strategies for Global Optimization

Damien Gerard, University of Liège, 10 Grande Traverse, Liège, 4000, Belgium, damien.gerard@ulg.ac.be, Matthias Koeppe, Quentin Louveaux

Spatial brand-and-bound is an algorithm to solve nonlinear optimization problems to global optimality. Most spatial branch-and-bound-based solvers use a nonglobal solver at a few nodes to try to find better incumbents. We propose new strategies to use these incumbents to improve the branching rules and the node priorities. We show computationally that the new strategies find the first good incumbents and prove the global optimality faster on benchmark instances.

3 - DC Decomposition of Nonconvex Polynomials with Algebraic Techniques

Georgina Hall, Princeton University, Department of ORFE, Princeton University, Sherrerd Hall, Charlton Street, Princeton, NJ, 08540, United States of America, gh4@princeton.edu, Amir Ali Ahmadi

The concave-convex procedure is a majorization-minimization algorithm for difference of convex (DC) optimization, where the constraints and the objective function are given as the difference of two convex functions. Although several important problems (e.g., in machine learning) already appear in DC form, such a decomposition is not always available. We consider this decomposition question for polynomial optimization. We introduce LP, SOCP, and SDP based algorithms for finding optimal DC decompositions by appealing to the algebraic concepts of "DSOS-Convex, SDSOS-Convex, and SOS-Convex" polynomials. We also study structural properties of these polynomials and answer existence questions about polynomial DC decompositions.

■ MD23

23- Allegheny

Dynamic Robust Optimization

Cluster: Robust Optimization

Invited Session

Chair: Wolfram Wiesemann, Imperial College Business School, South Kensington Campus, London, United Kingdom, ww@imperial.ac.uk

Co-Chair: Daniel Kuhn, EPFL, EPFL-CDM-MTEI-RAO, Station 5, Lausanne, Switzerland, daniel.kuhn@epfl.ch

1 - Robust Data-Driven Dynamic Programming

Grani Hanasusanto, Imperial College London, South Kensington Campus, London, United Kingdom, g.hanasusanto11@imperial.ac.uk, Daniel Kuhn

In stochastic optimal control the distribution of the exogenous noise is unknown and must be inferred from limited data before dynamic programming (DP)-based schemes can be applied. If the conditional expectations in the DP recursions are estimated via kernel regression, the historical sample paths can enter the solution procedure directly. The resulting data-driven DP scheme is asymptotically consistent and admits an efficient computational solution procedure. If training data is sparse, however, the corresponding control policies perform poorly in out-of-sample tests. To mitigate these small sample effects, we propose a robust data-driven DP scheme which dominates state-of-the-art benchmark algorithms across several application domains.

2 - Learning the Uncertainty in Robust Markov Decision Processes

Huan Xu, National University of Singapore, 9, Engineering Drive 1, Singapore, 117576, Singapore, mpexuh@nus.edu.sg, Shiau Hong Lim, Shie Mannor

A standard paradigm for MDP to tackle parameter uncertainty is robust MDP, which models the parameters as arbitrary element of predefined "uncertainty sets", and seeks the minimax policy. A challenge of robust MDP is how to find appropriate description of the uncertainty. In this talk we address this using an online learning approach: we devise an algorithm that, without knowing the true uncertainty model, is able to adapt its level of protection to uncertainty, and in the long run performs as good as the minimax policy as if the true uncertainty model is known. The algorithm achieves similar regret bounds as standard MDP, showing that with little extra cost we can adapt robust learning to handle uncertainty in MDPs.

3 - Two-Stage Robust Integer Programming

Wolfram Wiesemann, Imperial College Business School, South Kensington Campus, London, United Kingdom, ww@imperial.ac.uk, Grani Hanasusanto, Daniel Kuhn

In this talk we study two-stage robust optimization problems with integer recourse, which have largely resisted solution so far. To this end, we approximate the problems by their corresponding K-adaptability problems, in which the decision maker pre-commits to K second-stage policies here-and-now and implements the best of these policies once the uncertain parameters are observed. We study the approximation quality and the computational complexity of the K-adaptability problem, and we propose two mixed-integer linear programming reformulations that can be solved with off-the-shelf software.

■ MD24

24- Benedum

Computational Aspects of MINLP

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Armin Fügenschuh, Helmut Schmidt University / University of the Federal Armed Forces Hamburg, Holstenhofweg 85, Hamburg, 22043, Germany, fuegenschuh@hsu-hh.de

1 - Global and Local Optimal Control of Dynamical Systems

Ingmar Vierhaus, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, vierhaus@zib.de, Armin Fügenschuh

We consider the optimal control of dynamical systems, given in terms of a set of ordinary differential equations. We allow non-smooth functions in the model equations. Systems of this type can be transcribed into MINLPs and can then theoretically be solved globally with standard branch-and-bound solvers. However, in practice this is only feasible for very small instances. A branch-and-cut method based on the MINLP solver SCIP with taylored components for dynamical systems will be presented and compared to a local approach with smooth interpolations of the non-smooth functions. We present System Dynamics models from literature as test instances.

2 - Theoretical and Practical Aspects of Optimal Loop Extensions in Gas Networks

Ralf Lenz, Zuse Institute Berlin, Takustrasse 7, 14195 Berlin, Germany, lenz@zib.de, Felipe Serrano, Robert Schwarz

Gas network capacity is often increased by building pipes in parallel to existing ones, called loops. This leads to a nonconvex MINLP. A major difficulty in modeling are the nonlinear and nonconvex pressure loss constraints, while the mixed-integer part is due to the active elements. Since expansion costs are very high, we solve the model to global optimality, using outer approximation and spatial branching. We further strengthen our formulation by computing the convex envelope of the nonlinearities directly.

3 - Gas Network Optimization by MINLP

Jesco Humpola, Zuse Institute Berlin, Takustrafle 7, Berlin, 14195, Germany, humpola@zib.de

An algorithm for topology optimization of large-scale real-world natural gas transport networks is presented. The problem is modeled by an MINLP. The identification of the active transmission problem (ATP), which is obtained by fixing all discrete variables, is the key for solving the MINLP. The domain relaxation of the ATP has a wide range of beneficial mathematical properties. It gives rise to sufficient conditions for proving infeasibility of the ATP; a cut for the MINLP expressing the infeasibility of the ATP in an analogue way as the max-flow-min-cut-theorem of classical network flow theory; a primal heuristic based on parametric sensitivity analysis. Computational results obtained by a combination of SCIP and IPOpt are presented.

■ MD25

25- Board Room

CP Applications in Scheduling

Cluster: Constraint Programming

Invited Session

Chair: Louis-Martin Rousseau, CIRRELT - Ecole Polytechnique de Montreal, CP 6079 Succ Centre-Ville, Montreal, Canada, louis-martin.rousseau@cirrelt.net

1 - A Constraint Programming-Based Branch-and-Price-and-Cut for Operating Room Planning and Scheduling

Seyed Hossein Hashemi Doulabi, PhD Candidate, Ecole Polytechnique de Montreal, 2900 Boulevard Edouard-Montpetit, Montreal, QC, H3T 1J4, Canada, hashemi.doulabi@polymtl.ca, Gilles Pesant, Louis-Martin Rousseau

We present an efficient algorithm to solve an integrated operating room planning and scheduling problem which combines the assignment of surgeries to operating rooms and their scheduling over a short-term planning horizon. The problem is formulated as a mathematical programming model and a branch-and-price-and-cut algorithm is developed based on a constraint programming model to solve the subproblem. Some dominance rules and a fast infeasibility detection algorithm are also developed which effectively improve the efficiency of the constraint programming model. Computational results demonstrate that the proposed method significantly outperforms a compact mathematical formulation in the literature.

2 - Stochastic Optimization of the Scheduling of a Radiotherapy Center

Antoine Legrain, Polytechnique Montreal, Département de Mathématiques et de Génie, C.P. 6079, succ. Centre-ville, Montreal, Canada, antoine.legrain@polymtl.ca, Marino Widmer, Marie-Andrée Fortin, Nadia Lahrichi, Louis-Martin Rousseau

Cancer treatment facilities can improve their efficiency for radiation therapy by optimizing the utilization of linear accelerators and taking into account patient priority, treatment duration, and preparation of the treatment (dosimetry). The future workloads are inferred: a genetic algorithm schedules future tasks in dosimetry and a constraint program verifies the feasibility of a dosimetry planning. This approach ensures the beginning of the treatment on time and thus avoids cancellations.

3 - Retail Store Scheduling for Profit

Louis-Martin Rousseau, CIRRELT - Ecole Polytechnique de Montreal, CP 6079 succ Centre-Ville, Montreal, Canada, louis-martin.rousseau@cirrelt.net, Nicolas Chapados, Marc Joliveau, Pierre L'Écuyer

This paper frames the retail scheduling problem in terms of operating profit maximization, explicitly recognizing the dual role of sales employees as sources of revenues as well as generators of operating costs. We introduce a flexible stochastic model of retail store sales, estimated from store-specific historical data, that can account for the impact of all known sales driversn. We also present solution techniques based on mixed-integer (MIP) and constraint programming (CP) to efficiently solve the complex mixed integer non-linear scheduling (MINLP) problem with a profit-maximization objective.

■ MD26

26- Forbes Room

Mathematical Programming in Tax Policy Modeling

Cluster: Finance and Economics

Invited Session

Chair: Richard Evans, Assistant Professor, Brigham Young University, Department of Economics, 167 FOB, Provo, UT, 84602, United States of America, revans@byu.edu

1 - A Big Data Approach to Optimal Income Taxation

Kramer Quist, Brigham Young University, Macroeconomics and Computational Lab, 151 FOB, Provo, UT, 84602, United States of America, kramer.quist@gmail.com, Jeremy Bejarano, Richard Evans, Ken Judd, Kerk Phillips

We characterize and demonstrate a solution method for an optimal income tax problem with heterogeneous agents and a nonconvex policy maker optimization problem. Our approach allows for more dimensions of heterogeneity than has been previously possible, incorporates potential model uncertainty and policy objective uncertainty, and relaxes some of the assumptions in the previous literature that were necessary to generate a convex optimization problem for the policy maker. Our solution technique involves creating a large database of optimal responses by different individuals for different policy parameters and using ``big data" techniques to compute policy maker objective values over these individuals.

2 - The Distributional Effects of Redistributional Tax Policy

Richard Evans, Assistant Professor, Brigham Young University, Department of Economics, 167 FOB, Provo, UT, 84602, United States of America, revans@byu.edu, Jason DeBacker, Kerk Phillips

This paper constructs a large scale overlapping generations model with heterogeneity across the life cycle and lifetime income groups. We consider the effects of two policies that have the same steady-state revenue effect: an increase in income tax rates and a progressive wealth tax. We find that a more progressive income tax does reduces measures of cross-sectional inequality in consumption, income, and wealth. In contrast, a wealth tax reduces cross sectional inequality by reducing inequality over the life cycle, but a wealth tax slightly increases inequality across lifetime income groups.

3 - A Large-Scale Macroeconomic Model for Dynamic Scoring

Jason DeBacker, Assistant Professor, Middle Tennessee State University, Department of Economics and Finance, P.O. Box 27, Murfreesboro, TN, 37132, United States of America, jason.debacker@gmail.com, Richard Evans, Kerk Phillips, Evan Magnusspon, Isaac Swift

We construct a large scaled dynamic general equilibrium model to evaluate tax policy. The model includes households with heterogeneous lifecycle earnings profiles, realistic demographics, and a rich set of production industries. Together, these features allow the model to analyze revenue, economic, and distributional impacts of a wide range of tax policies. Our solution method allows for the estimation of impacts of temporary policies and for the transition paths of permanent policy changes, not just long run analyses. A additional key feature of the model is its open source nature, which will allow policy makers and researchers to further customize and improve the model.

■ MD27

27- Duquesne Room

Sparse Optimization and Compressed Sensing

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Vincent LeclereResearcher, ENPC, 6-8 av. Blaise Pascal, Champs-sur-Marne, 77455, France, vincent.leclere@cermics.enpc.fr

1 - Fast Imbalanced Binary Classification: A Moment-based Approach

Vincent Leclere, Researcher, ENPC, 6-8 av. Blaise Pascal, Champs-sur-Marne, 77455, France, vincent.leclere@cermics.enpc.fr, Edouard Grave, Laurent El Ghaoui

We consider the problem of imbalanced binary classification in which the number of negative examples is much larger than the number of positive examples. We represent the negative class by the two first moments of its probability distribution, while still modeling the positive class by individual examples. Minimizing the probability of misclassification lead to a formulation comparable to an SVM approach. However, our formulation does not depend on the number of negative examples, making it suitable to highly imbalanced problems and scalable to large datasets.

2 - Optimization Algorithms for Model Selection in High-Dimensional Case-Control Genome-Wide Association

Kevin Keys, UCLA, Box 951766, Life Sciences #5303, 621 Charles E Young Drive South, Los Angeles, CA, 90095, United States of America, klkeysb@gmail.com, Gary Chen, Kenneth Lange

Genome-wide association studies (GWASes) examine genetic variation genotyped on microarrays between groups of patients with distinguishable phenotypes. Accurately selecting genetic markers informative for disease remains a difficult computational problem in very high dimensions. We implement iterative hard thresholding to select these informative genetic markers on full-scale GWAS data. Our implementation exploits parallel computing and data compression paradigms to facilitate GWAS analysis on desktop machines and to effectively ameliorate the computational burden of GWAS model selection.

3 - Guaranteed Matrix Completion via Non-Convex Factorization

Ruoyu Sun, University of Minnesota, 200 Union St., SE, Minneapolis, MN, 55455, United States of America, sunxx394@umn.edu, Zhi-Quan Luo

Matrix factorization based optimization is a popular approach for large-scale matrix completion. However, due to the non-convexity, there is a limited theoretical understanding of this approach. We show that under similar conditions to those in previous works, many standard optimization algorithms converge to the global optima of the factorization based formulation, thus recovering the true low-rank matrix. To the best of our knowledge, our result is the first one that provides recovery guarantee for many standard algorithms such as gradient descent, SGD and block coordinate gradient descent.

■ MD28

28- Liberty Room

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Miawjane Chen, Professor, National United University, 1, Lienda, Miaoli, 36003, Taiwan - ROC, mjchen@nuu.edu.tw

1 - Optimizing Bounds on Cell Counts in Contingency Tables of Rounded Conditional Frequencies

Stephen E. Wright, Miami University, Dept of Statistics, Oxford, OH, 45056, United States of America, wrightse@miamioh.edu, Andrew Sage

We discuss an integer linear optimization formulation for the problem of determining tightest bounds on cell counts in a multi-way contingency table, given knowledge of a corresponding two-way table of rounded conditional probabilities. The formulation admits a three-phase decomposition with master subproblem solvable in closed form and worker subproblems addressed simultaneously in a divide-and-conquer implementation of dynamic programming. The proposed procedure finds all possible counts (not just bounds) for each cell and runs fast enough to handle moderately sized tables.

2 - Network Flow Models for Project Scheduling with Discount Cash Flows under Stochastic Work Durations

Miawjane Chen, Professor, National United University, 1, Lienda, Miaoli, 36003, Taiwan - ROC, mjchen@nuu.edu.tw, Ru-San Wei, Shangyao Yan, Yi-Chun Chen, Cheng-Han Tsai

In this study, we employ a network flow technique to develop two multi-mode resource-constrained project scheduling models with discount cash flows under stochastic work durations, using the payment at activity completion times and the lump sum payment. These models are formulated as an integer network flow problem with side constraints. An evaluation method is also developed to evaluate these models in simulated operations. Finally, numerical examples are designed to test the applicability of the models. The test results are good showing that the models could be suitable planning tools for decision makers in real operations.

3 - An Integer Programming Formulation of the Polymorphic Alu Insertion Recognition Problem

Luciano Porretta, Université Libre de Bruxelles - Graphes et Optimisation Mathematique, Boulevard du Triomphe, CP 210/01, Bruxelles, Belgium, lporrett@ulb.ac.be, Bjarni V. Haldórsson, Bernard Fortz

Alu polymorphisms are some of the most common polymorphisms in the genome, yet few methods have been developed for their detection. We present an algorithm to discover Alu polymorphisms using paired-end high throughput sequencing data from multiple individuals. We consider the problem of identifying sites containing polymorphic Alu insertions. We give an efficient and practical algorithm that detect polymorphic Alus that are inserted with respect to the reference genome.

■ MD29

29- Commonwealth 1

Nonsmooth Optimization in Data Sciences

Cluster: Nonsmooth Optimization

Invited Session

Chair: Jalal Fadili, Professor, CNRS-ENSICAEN-Univ. Caen, 6 Bd Marechal Juin, Caen, 14050, France, Jalal.Fadili@ensicaen.fr

1 - Serialrank: Spectral Ranking using Seriation

Alexandre d'Aspremont, CNRS - ENS Paris, 23 av. d'Italie, Paris, France, alexandre.daspremont@m4x.org, Fajwel Fogel, Milan Vojnovic

We describe a seriation algorithm for ranking a set of n items given pairwise comparisons between these items. Intuitively, the algorithm assigns similar rankings to items that compare similarly with all others. It does so by constructing a similarity matrix from pairwise comparisons, using seriation methods to reorder this matrix and construct a ranking. We first show that this spectral seriation algorithm recovers the true ranking when all pairwise comparisons are observed and consistent with a total order. We then show sample optimality. An additional benefit of the seriation formulation is that it allows us to solve semi-supervised ranking problems. We detail experiments on both synthetic and real datasets.

2 - Convergence Analysis for Stochastic Forward-Backward Splitting

Silvia Villa, LCSL, Istituto Italiano di Tecnologia & Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 0, Italy, silvia.villa@iit.it, Bang Vu, Lorenzo Rosasco

I will analyze the convergence of a novel stochastic forward-backward splitting algorithm for solving monotone inclusions given by the sum of a maximal monotone operator and a single-valued maximal monotone cocoercive operator. This latter framework has a number of interesting special cases, including variational inequalities and convex minimization problems, while stochastic approaches are practically relevant to account for perturbations in the data. The algorithm I will discuss is a stochastic extension of the classical deterministic forward-backward method, and is obtained considering the composition of the resolvent of the maximal monotone operator with a forward step based on a stochastic estimate of the single-valued operator.

3 - A Recursive Splitting Method for Nonsmooth-Nonconvex Optimization and Application to X-ray Imaging

Russell Luke, University of Goettingen, Institute for Numerical and Applied Math, Goettingen, 39083, Germany, r.luke@math.uni-goettingen.de

We propose a general alternating minimization algorithm for nonconvex optimization problems with separable structure and nonconvex coupling between blocks of variables. To fix our ideas, we apply the methodology to the problem of blind ptychographic imaging. Compared to other schemes in the literature, our approach differs in two ways: (i) it is posed within a clear mathematical framework with practically verifiable assumptions, and (ii) under the given assumptions, it is provably convergent to critical points. A numerical comparison of our proposed algorithm with the current state-of-the-art on simulated and experimental data validates our approach and points toward directions for further improvement.

■ MD30

30- Commonwealth 2

Approximation and Online Algorithms III

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Bobby Kleinberg, Cornell University, Department of Computer Science, 402 Gates Hall, Ithaca, NY, 14850, United States of America, rdk@cs.cornell.edu

1 - Almost Matching Upper and Lower Bounds for Vector Scheduling

Tjark Vredeveld, Maastricht University, P.O. Box 616, Maastricht, 6200MD, Netherlands, t.vredeveld@maastrichtuniversity.nl, Ruben Van der Zwaan, Tim Oosterwijk, Nikhil Bansal

We consider the Vector Scheduling problem, a natural generalization of the classical makespan minimization problem to multiple resources. For fixed dimension of the vectors, the problem admits an approximation scheme, and the best known running time is double exponential in the dimension. We show that a double exponential dependence on the dimension is necessary, and give an improved algorithm with essentially optimal running time.

2 - Competitive Algorithms from Competitive Equilibria

Kamesh Munagala, Duke University, D205 LSRC Building, 308 Research Drive, Durham, NC, 27708, United States of America, kamesh@cs.duke.edu, Sungjin Im, Janardhan Kulkarni

In this talk, we introduce a general scheduling problem that we term the Packing Scheduling problem (PSP). In this problem, jobs have different arrival times and sizes, and the rates at which a scheduler can process jobs are subject to arbitrary packing constraints. The PSP framework captures many classical scheduling problems, as well as multidimensional resource requirements that arise in cluster computing. We design non-clairvoyant online algorithms for PSP. For minimizing total weighted completion time, we show a constant competitive algorithm. Surprisingly, we achieve this result by applying the well-known Proportional Fairness algorithm from economics to allocate resources each time instant.

3 - Incentivizing Exploration

Bobby Kleinberg, Cornell University, Department of Computer Science, 402 Gates Hall, Ithaca, NY, 14850, United States of America, rdk@cs.cornell.edu, Peter Frazier, David Kempe, Jon Kleinberg

Many on-line social systems depend upon accumulating information about diverse alternatives from a crowd of autonomous users. Examples include product recommendations, social news readers, and crowdsourced "citizen science". These domains suffer from misaligned incentives: the designer aims to efficiently explore a space of alternatives, while users aim to optimize the alternatives they select. We model this as a multi-armed bandit problem in which selfish agents pull arms with publically observable outcomes, and a principal may influence them with rewards contingent on their choice of arm. Our main result quantifies the trade-off between the expected payments the principal makes and the total time-discounted reward that can be achieved.

Monday, 4:35pm - 5:25pm

■ ME01

01- Grand 1

Equilibrium Routing under Uncertainty

Cluster: Plenary

Invited Session

Chair: Andrzej Ruszczynski, Rutgers University, 100 Rockefeller Road, Piscataway, NJ, 08854, United States of America, rusz@business.rutgers.edu

1 - Equilibrium Routing under Uncertainty

Roberto Cominetti, University of Chile, Republica 701, Sabtiago, Chile, rccc@dii.uchile.cl

In this talk we review several alternative models that have been used to describe traffic in congested networks, both in urban transport and telecommunications. We focus on situations where travel times are subject to random fluctuations and how this variability affects the traffic flows. We consider both atomic and non-atomic equilibrium models, and we discuss a class of adaptive dynamics that describe the behavior of agents and which provides a plausible micro-foundation for the emergence of equilibrium. We also discuss some recent ideas on how risk aversion to random travel times might be incorporated in the models. In our presentation we use convex optimization to provide a unifying framework for the different concepts of equilibrium.

■ ME02

02- Grand 2

Complexity, Approximation, and Relaxation of the Power Flow Equations

Cluster: Plenary

Invited Session

Chair: Laurence WolseyEmeritus, Professor, CORE,University of Louvain, Voie du Roman Pays 34, Louvain-la-Neuve, 1348, Belgium, laurence.wolsey@uclouvain.be

1 - Complexity, Approximation, and Relaxation of the Power Flow Equations

Pascal Van Hentenryck, Professor, NICTA/ANU, Australia, pvh@nicta.com.au

The design, control, and operation of the power grid, probably the largest and most expansive system ever engineered, require the solving of optimization problems over the steady-state power flow equations. The resulting mixed nonconvex programs are often computationally challenging and increasingly so with the increased stochasticity in generation and load. This talk presents some new complexity results, as well as a number of advances in approximating and relaxing the power flow equations to address emerging applications in power systems, including large-scale power restoration after blackouts, the design of resilient networks, and the integration of renewable generation. Extensive computational results demonstrate some of the benefits of the proposed techniques.

Monday, 5:30pm - 7:00pm

■ MF01

01- Grand 1

Variational Analysis Techniques over Symmetric Cones

Cluster: Variational Analysis

Invited Session

Chair: Hector Ramirez, Universidad de Chile, Beauchef 851, Piso 5, Santiago, Chile, hramirez@dim.uchile.cl

1 - Commutation Principle for Variational Problems on Euclidean Jordan Algebras

David Sossa, Universidad Técnica Federico Santa Marìa, Avda España 1680, Valparaiso, Chile, dsossa@dim.uchile.cl, Hector Ramirez, Alberto Seeger

We establish a commutation result for variational problems involving spectral sets and spectral functions. The discussion takes places in the context of a general Euclidean Jordan algebra.

2 - Self-Duality and Non-Expansiveness of the Resolvent Average on JB-Algebras

Sangho Kum, Professor, Chungbuk National University, 1 Chungdae-ro, Seowon-Gu, Cheongju, 362-763, Korea, Republic of, shkum@chungbuk.ac.kr

We establish self-duality of the resolvent average dened on the symmetric cone of a JB-algebra. It induces the monotonicity of the resolvent average and the geometric mean of arithmetic and harmonic means for parameters. Nonexpansive property of these means for the Thompson metric on the cone and its applications to nonlinear equations are given.

3 - Characterization of Qb-Transformations for Linear Complementarity Problems over Symmetric Cones

Julio Lopez, Universdad Diego Portales, Av. Ejército 441, Santiago, Chile, julio.lopez@udp.cl, Reuben López, Hector Ramirez

In this work, our aim is to characterize the class of linear transformations for which the symmetric cone linear complementarity problem (SCLCP) has always a nonempty and bounded solution set in terms of larger classes. For this, we introduce a couple of new classes of linear transformations in this SCLCP context. Then, we study them for concrete particular instances (such as second-order and semidefinite linear complementarity problems) and for specific examples (Lyapunov, Stein functions, among others).

■ MF02

02- Grand 2

Equilibrium and Stochastic Models for Energy Systems

Cluster: Optimization in Energy Systems

Invited Session

Chair: Miguel Anjos, Professor and Canada Research Chair, Polytechnique Montreal, C.P. 6079, succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, miguel-f.anjos@polymtl.ca

1 - Value of Flexible Resources in Wind-Integrated Electricity Markets: A Stochastic Equilibrium Analysis

Venkat Prava, Ph D Candidate, Johns Hopkins University, 3400 North Charles Street, Baltimore, MD, 21218, United States of America, vprava1@jhu.edu, S. Jalal Kazempour, Benjamin Hobbs, Judith Cardell, Lindsay Anderson

We analyze the value of diverse operational flexible resources (peak units, demand response and virtual bidding) in a two-settlement wind-integrated electricity market (including day-ahead and real-time). To this end, a stochastic equilibrium model is characterized through a simultaneous clearing of day-ahead and real-time markets. Wind power uncertainty is represented by a set of scenarios. The upward and downward demand responses are considered in both markets.

2 - Stochastic Market Clearing: An Adequate Pricing Scheme Per Scenario

S. Jalal Kazempour, Postdoc, Technical University of Denmark, Department of Electrical Engineering, Akademivej, Building 358, Room 132, Kgs. Lyngby, 2800, Denmark, seykaz@elektro.dtu.dk, Pierre Pinson

The available stochastic market clearing tools in the literature guarantee revenue adequacy in the market and non-negative profit for all producers (conventional and renewable) in expectation only. This has been criticized since those criteria are not guaranteed per scenario. We propose an equilibrium model rendering a MILP that is revenue adequate per scenario and for which each producer’s profit is also non-negative per scenario.

3 - Partially Adaptive Stochastic Optimization for Electric Power Generation Expansion Planning

Jikai Zou, Research Assistant, Georgia Institute of Technology, 765 Ferst Drive, Room 446 Main Bld., Atlanta, GA, 30309, United States of America, jikai.zou@gatech.edu, Shabbir Ahmed, Andy Sun

We consider a stochastic optimization approach for power generation expansion planning problem under demand and fuel price uncertainty. We propose a partially adaptive stochastic mixed integer optimization model in which the capacity expansion plan is fully adaptive to the uncertainty evolution up to a certain period, and future plan are determined prior to further uncertainty realizations. We provide analytical bounds on solution quality. We also propose an algorithm that solves a sequence of partially adaptive models, to recursively construct an approximate multistage solution. We identify sufficient conditions under which this algorithm recovers an optimal multistage solution. Computational results on a realistic instance are discussed.

■ MF03

03- Grand 3

Optimization under Uncertainty II

Cluster: Combinatorial Optimization

Invited Session

Chair: Marc Uetz, University of Twente, P.O. Box 217, Enschede, 7500AE, Netherlands, m.uetz@utwente.nl

1 - Packing a Knapsack of Unknown Capacity

Yann Disser, TU Berlin, Institut für Mathematik, Sekr. MA 5-2, Strasse des 17. Juni 136, Berlin, Germany, disser@math.tu-berlin.de, Max Klimm, Nicole Megow, Sebastian Stiller

We study the problem of packing a knapsack without knowing its capacity. Whenever we attempt to pack an item that does not fit, the item is discarded; if the item fits, we have to include it in the packing. We show that there is always a policy that packs a value within factor 2 of the optimum packing, irrespective of the actual capacity. If all items have unit density, we achieve a factor equal to the golden ratio 1.618. Both factors are shown to be best possible. We give efficient algorithms computing the above policies and show that the problem of deciding whether a given policy achieves a factor of a>1 or whether a "universal" policy achieving this factor exists is coNP-complete.

2 - Two-stage Stochastic and Robust Scheduling

Nicole Megow, Technische Universitaet Berlin, Strasse des 17. Juni 136, Berlin, 10623, Germany, nmegow@math.tu-berlin.de, Lin Chen, Roman Rischke, Leen Stougie

We propose a natural model for two-stage scheduling under uncertainty. Reserving a time unit for processing jobs incurs some cost, which depends on when the reservation is made: a priori decisions, based only on distributional information, are much cheaper than on-demand decisions when the actual scenario is known. We consider both stochastic and robust versions of scheduling unrelated machines with the objectives of minimizing the sum of weighted completion times and the makespan. We give constant-factor approximations which hold for an arbitrary scenario distribution given by means of a black-box. Our techniques also yield approximation algorithms for robust two-stage scheduling.

3 - Robust Randomized Matchings

Martin Skutella, Professor. Dr., TU Berlin, Strafle des 17. Juni 136, Fak, II, Mathematik, Sekr. MA 5-2, Berlin, 10623, Germany, martin.skutella@tu-berlin.de, Jose Soto, Jannik Matuschke

The following zero-sum game is played on a weighted graph G: Alice selects a matching M and Bob selects a number k. Then, Alice receives a payoff equal to the ratio of the weight of the top k edges of M to the maximum weight of a matching of size at most k in G. If M guarantees a payoff of at least α, then it is called α-robust. Hassin and Rubinstein (2002) gave an algorithm that returns a $1/\sqrt{2}$-robust matching, which is best possible for this setting. We give a new, LP-based proof of their result. Moreover, we show that Alice can improve her payoff by playing a randomized strategy. For this setting, we devise a simple algorithm that returns a $1/\ln(4)$-robust randomized matching.

■ MF04

04- Grand 4

Advances and Applications in Conic Optimization Part I

Cluster: Conic Programming

Invited Session

Chair: Makoto YamashitaDr, Tokyo Institute of Technology, 2-12-1-W8-29, Oookayama, Meguro-ku, Tokyo, 152-8552, Japan, Makoto.Yamashita@is.titech.ac.jp

Co-Chair: Akiko Yoshise, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki, Tsukuba, Ib, 305-8573, Japan, yoshise@sk.tsukuba.ac.jp

1 - Optimization Model for Estimating Quantum Yield Distribution in Photochromic Reaction

Mirai Tanaka, Tokyo University of Science, 2641 Yamazaki, Noda, Chiba, 278-8510, Japan, mirai@rs.tus.ac.jp, Takashi Yamashita, Mizuho Nagata, Natsuki Sano, Aya Ishigaki, Tomomichi Suzuki

In this talk, an optimization model arising from photochemistry is proposed. In a photochromic reaction, the ratio of the number of reacted molecules and that of absorbed photon is called the quantum yield. The quantum yield of a photochromic reaction in solid polymer has distribution. The estimation of the quantum yield distribution has the importance in material engineering. To estimate the distribution, the authors formulate the minimization of the L2-distance between measured values of absorbance in the reaction and theoretical ones as a convex quadratic optimization problem over a functional space with ODE constraints derived from a reaction rate equation. The authors derive a convex quadratic optimization model with discretization.

2 - Feature Subset Selection for Linear/Logistic Regression via Mixed Integer Optimization

Yuichi Takano, Senshu University, 2-1-1 Higashimita, Tama-ku, Kawasaki-shi, 214-8580, Japan, ytakano@isc.senshu-u.ac.jp

This talk deals with the methods of selecting a subset of features for linear/logistic regression models. The subset selection problem for linear regression is formulated as a mixed integer second-order cone optimization problem by employing information criteria (e.g., AIC and BIC) as a goodness-of-fit measure. The problem for logistic regression is posed as a mixed integer linear optimization problem by using a piecewise linear approximation.

3 - Rank Minimization Approach to Collaborative Filtering Based on the Nuclear Norm Minimization

Tomotaka Yokoo, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki, Tsukuba-shi, Japan, s1420495@sk.tsukuba.ac.jp, Akiko Yoshise

Recht, Fazel and Parrilo(2010) gave a theoretical characterization of the nuclear norm minimization relaxation of the affine rank minimization problem and suggested many applications of the result including collaborative filtering.However, very few results have been reported on collaborative filtering using the rank minimization approach.In this talk, we will present some numerical results using this approach and compare them with the results using singular value decomposition approach.

■ MF05

05- Kings Garden 1

Higher Order Methods for Regularization Problems

Cluster: Nonlinear Programming

Invited Session

Chair: Kimon Fountoulakis, The University of Edinburgh, k.fountoulakis@sms.ed.ac.uk

1 - In-Network Nonconvex Optimization

Gesualdo Scutari, Assistant Professor, SUNY Buffalo, North Campus, Buffalo, NY, 14260, United States of America, gesualdo@buffalo.edu, Paolo Di Lorenzo, Francisco Faccinei

Consider a network composed of agents aiming to distributively minimize a (nonconvex) smooth sum-utility function plus a nonsmooth (nonseparable), convex one. The agents have access only to their local functions but not the whole objective, and the network is modeled as a directed, time-varying, B-strongly connected graph. We propose a distributed solution method for the above optimization wherein the agents in parallel minimize a convex surrogate of the original nonconvex objective while using consensus to distribute the computations over the network. Convergence to stationary solutions is established. Numerical results show that our new algorithm outperforms current schemes on both convex and nonconvex problems.

2 - Conic Geometric Optimisation on the Manifold of Positive Definite Matrices

Suvrit Sra, MIT, 77 Massachusetts Ave, Cambridge, MA, 02139, United States of America, suvrit@mit.edu

We develop geometric optimisation on the manifold of positive definite (PD) matrices. In particular, we consider two types of cost functions: (i) geodesically convex (g-convex); and (ii) log-nonexpansive (LN). G-convex functions are nonconvex in the Euclidean sense, but convex along the manifold, and thus globally optimisable. LN functions may fail to be g-convex, but are still globally optimisable due to their special structure. We develop theoretical tools to recognise and construct g-convex and LN functions. To optimise them, we develop both manifold BFGS and fixed-point algorithms (the latter outdo manifold methods). Remarkably, even in the case of certain convex PD problems, our algorithms greatly outperform the usual SDP solvers.

3 - Preconditioners for Higher Order Methods in Big Data Optimization

Jacek Gondzio, Professor, University of Edinburgh, King's Buildings, Edinburgh, Edinburgh, EH9 3FD, United Kingdom, J.Gondzio@ed.ac.uk, Kimon Fountoulakis

We address efficient preconditioning techniques for the second-order methods applied to solve various sparse approximation problems arising in big data optimization. The preconditioners cleverly exploit special features of such problems and cluster the spectrum of eigenvalues around one. The inexact Newton Conjugate Gradient method excels in these conditions. Numerical results of solving L1-regularization problems of unprecedented sizes will be presented.

■ MF06

06- Kings Garden 2

Optimizing Network Design

Cluster: Telecommunications and Networks

Invited Session

Chair: Austin Buchanan, Texas A&M University, TAMU-3131, College Station, TX, United States of America, buchanan@tamu.edu

1 - Capacity Planning for the Google Backbone Network

Emilie Danna, Google, 1600 Amphitheatre Pkwy, Mountain View, CA, 94043, United States of America, edanna@google.com, Ajay Bangla, Wenjie Jiang, Bikash Koley, Ben Preskill, Xiaoxue Zhao, Christoph Albrecht, Alireza Ghaffarkhah

Google operates one of the largest backbone networks in the world. In this talk, we present optimization and simulation techniques we use to design the network topology and provision its capacity to achieve conflicting objectives such as scale, cost, availability, and latency.

2 - Virtual Network Embedding Problems with Time Windows

Andreas Bley, Universitaet Kassel, Heinrich-Plett-Str. 40, Kassel, Germany, andreas.bley@mathematik.uni-kassel.de, Frank Fischer

The goal of the classical virtual network (VN) embedding problem (VNEP) is to embed a graph representing a VN in a physical substrate network. Edges of the VN must be mapped to paths in the substrate network. The embedding must observe certain capacity constraints at the nodes and edges of the substrate network like CPU power or bandwidth. Whereas in the VNEP all requests are embedded at the same time, we consider requests that have a time window and a duration specifying when and how long they should be embedded. All capacity constraints must be satisfied at each point in time. This combines the VNEP with a scheduling problem. We present and compare first mixed integer programming models and provide some preliminary computational results.

3 - Computational Experiments for the Simple Cycle Problem

Abilio Lucena, Dr., Federal University of Rio de Janeiro, Cidade Universitaria, Centro Tec., Bloco H, sala 319, Rio de Janeiro, RJ, 21941-972, Brazil, abiliolucena@globo.com, Alexandre Salles da Cunha, Luidi Simonetti

Given an edge weighted connected undirected graph G, two different formulations are investigated for the Simple Cycle Problem, the problem of finding a least cost simple cycle of G. Additionally, we also consider extensions of these formulations to the Prize Collecting Traveling Salesman Problem and the Ring-Star Problem. Computational results are presented for Branch and Cut algorithms for these three problems.

■ MF07

07- Kings Garden 3

Large-Scale Machine Learning

Cluster: Nonsmooth Optimization

Invited Session

Chair: Martin Takac, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, United States of America, martin.taki@gmail.com

Co-Chair: Martin Jaggi, Universitaetsstr 6, Zürich, 8092, Switzerland, jaggi@inf.ethz.ch

1 - Efficient Hierarchical Multi-Label Learning

Xiaocheng Tang, Lehigh University, 200 West Packer Avenue, Bethlhem, PA, United States of America, xiaocheng.t@gmail.com

Hierarchical Multi-label Learning (HML) has found applications in ad targeting or document classification where labels are organized in a connected (tree) structure. Existing approaches, however, do not adequately address the keys of HML: 1) how to exploit the hierarchy structure during training; and 2) how to preserve the same structure during prediction. Here we propose a novel, efficient two-stage HML model that directly addresses both of these problems, and we demonstrate HML on large-scale real-world data sets from document classification, as well as ad targeting domains that involves two million users' daily activities. The results indicate that the proposed approach outperforms traditional multi-label learning models on both tasks.

2 - SAGA: A Fast Incremental Gradient Method with Support for Non-Strongly Convex Composite Objectives

Simon Lacoste-Julien, INRIA, 23 avenue d'Italie, Paris, 75013, France, simon.lacoste-julien@inria.fr, Aaron Defazio, Francis Bach

Minimizing the sum of n functions where n can be very large has been a central optimization problem appearing in machine learning and other fields. Several incremental gradient algorithms were proposed in the last few years where every step is cheap (accessing only one function), while still obtaining a fast global linear convergence rate that can improve over batch gradient methods. In this talk, I will present an overview of these methods, using the unifying perspective of variance reduction. I will also present an incremental gradient method that supports composite optimization (with a prox operator) and that is adaptive to any strong convexity in the problem (the same step-size can be used for strongly and non-strongly convex problems).

3 - mS2GD: Mini-Batch Semi-Stochastic Gradient Descent in the Proximal Setting

Jie Liu, Lehigh University, Industrial and Systems Engineering Dept., 200 West Packer Ave., Bethlehem, PA, 18015, jild13@lehigh.edu, Martin Takac, Peter Richtarik, Jakub Konecny

We propose mS2GD method applied to minimizing a strongly convex composite function represented as the sum of an average of large numbers of smooth convex functions, and a simple nonsmooth convex function. Our mS2GD method benefits from two speedup effects. First, as long as mini-batch size is below a certain threshold, we can reach predefined accuracy with less overall work than without mini-batching. Second, our mini-batching scheme admits a simple parallel implementation for further acceleration.

■ MF08

08- Kings Garden 4

Resilience in Network Design

Cluster: Combinatorial Optimization

Invited Session

Chair: Neil Olver, VU University Amsterdam & CWI, De Boelelaan 1105, 1081 HV, Amsterdam, Netherlands, olver@cwi.nl

1 - An O(1)-Approximation for Minimum Spanning Tree Interdiction

Rico Zenklusen, ETH Zurich, Ramistrasse 101, HG G 21.3, Zurich, 8092, Switzerland, ricoz@math.ethz.ch

Network interdiction studies the maximum impact that a removal of a limited number of edges or vertices can have on a graph optimization problem. Most interdiction problems are NP-hard, and only little is known about their approximability. One of the oldest and most-studied interdiction problems is minimum spanning tree (MST) interdiction. Here, an MST problem is given together with positive edge costs and a budget B. The goal is to remove edges of total cost at most B such that an MST in the resulting graph is as heavy as possible. So far, the best approximation was a nearly two-decades-old O(log(n))-approximation by Frederickson and Solis-Oba (SODA 1996). In this talk we show that MST interdiction admits an O(1)-approximation.

2 - Packing Interdiction and Partial Covering Problems

Michael Dinitz, Johns Hopkins University, United States of America, mdinitz@cs.jhu.edu, Anupam Gupta

In the Packing Interdiction problem we are given a packing LP together with a separate interdiction cost for each LP variable and a global interdiction budget. Our goal is to harm the LP: which variables should we forbid the LP from using (subject to staying within the budget) in order to minimize the value of the resulting LP? We give an O(log q min{q, log k})-approximation to Packing Interdiction, where q is the row-sparsity of the packing LP and k is the column-sparsity. As a corollary, we give the first O(1)-approximation to weighted matching interdiction in graphs.

3 - Stable and b-stable Set interdiction on Bipartite Graphs

Stephen Chestnut, Johns Hopkins University, 3400 N. Charles St., Baltimore, MD, 21218, United States of America, schestn2@jhu.edu, Rico Zenklusen

One way to evaluate the robustness of a system is to understand interdiction, or attack, strategies. Given is an optimization problem along with some rules and a budget for modifying the feasible set with the goal of inducing the worst possible change in the objective. In this talk I will outline efficient algorithms for solving stable set interdiction and approximating b-stable set interdiction when the underlying graph is bipartite. Along the way we will come across a polyhedral tool, first used by Burch et al. (2003), that can be applied for pseudo-approximation algorithms to many other combinatorial optimization problems.

■ MF09

09- Kings Garden 5

Semidefinite Hierarchies for Approximations in Combinatorial Optimization I

Cluster: Combinatorial Optimization

Invited Session

Chair: Nikhil Bansal, Dr., Technical University Eindhoven, Eindhoven, Netherlands, bansal@gmail.com

Co-Chair: Monique Laurent, CWI & Tilburg University, Science Park 123, Amsterdam, Netherlands, M.Laurent@cwi.nl

1 - Sparsest Cut on Bounded Treewidth Graphs: Algorithms and Hardness Results

David Witmer, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, dwitmer@cs.cmu.edu, Anupam Gupta, Kunal Talwar

We give a 2-approximation algorithm for Non-Uniform Sparsest Cut on bounded treewidth graphs. Our algorithm rounds the Sherali-Adams lift of the standard Sparsest Cut LP. We show that even for treewidth-2 graphs, the LP has an integrality gap close to 2. Hence our approach cannot be improved even on such restricted graphs without using a stronger relaxation. We also show the following hardness results: If Non-Uniform Sparsest Cut has an r-approximation for treewidth-2 graphs, then Max Cut has a 1/r approximation. Hence, even for such restricted graphs, Sparsest Cut is NP-hard to approximate better than 17/16. For graphs with large (but constant) treewidth, we show a hardness of 2 assuming the Unique Games Conjecture.

2 - A Comparison of SDP Hierarchies and Mixed SDP/LP Hierarchies

Eden Chlamtac, Dr., Ben-Gurion University of the Negev, Dept of Computer Science, P.O. Box 653, Beer-Sheva, 84105, Israel, chlamtac@cs.bgu.ac.il

We consider mixed hierarchies of relaxations. That is, hierarchies derived by taking an LP hierarchy (e.g. Sherali-Adams), and adding a PSD constraint on the second moment matrix (indexed by singletons and by the empty set). These hierarchies have been shown to be algorithmically useful, and for some problems, they represent the strongest relaxations for which we can provably construct strong integrality gaps. Despite the evident strength of mixed-hierarchies, we note two instances where proper SDP hierarchies, such as LS+ or Lasserre, give qualitatively better approximations than mixed hierarchies (either by giving a good approximation at a fixed level, or by giving a PTAS where mixed hierarchies require a linear number of rounds).

3 - Learning and Optimization via the Sum of Squares Algorithm

Boaz Barak, Dr., Microsoft Research New England, 1 Memorial Drive, Cambridge, MA 02142, United States of America, b@boazbarak.org

The Sum-of-Squares (SOS) Algorithm is a powerful framework for polynomial optimization using semidefinite programming. I will present some recent results using the SOS algorithm to obtain approximation algorithms and solve various unsupervised learning tasks, including sparse coding (aka dictionary learning) tensor prediction. I will discuss how the SOS algorithm yields a different viewpoint on algorithm design, where instead of focusing on finding a solution to a given instance, we try to find a “hay in a haystack” in the sense of extracting a single solution from the low order moments of a distribution over all solutions. Talk will be based on joint works with Jonathan Kelner, Ankur Moitra, and David Steurer.

■ MF10

10- Kings Terrace

Logistics Traffic and Tranportation

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Laurent Daudet, PhD Student, Ecole des Ponts Paris Tech, 6,8 av. Blaise Pascal, Marne-la-Vallée, 77455, France, laurent.daudet@cermics.enpc.fr

1 - POP-based Approximation Method Enabled by Physical ILP Model for Static Elevator Operation Problems

Tsutomu Inamoto, Ehime University, Bunkyo 3, Matsuyama, Japan, inamoto@ehime-u.ac.jp, Yoshinobu Higami, Shin-ya Kobayashi

In this paper, we propose an approximation method for an integer linear programming model for the problem of scheduling elevator movements. The ILP model is based on trips each of which represents one directional movement of an elevator, and in that model movements of elevators are scheduled by assigning passengers to trips. That model brings such a difficulty that we have to specify minimum required numbers of trips, but brings such a POP characteristic that if we have two settings which are similar in numbers of given trips, then assignments of passengers are also similar between optimal solutions of those two settings. The proposed method is numerically evaluated by solving many problem instances using a mathematical solver.

2 - Optimized Scheduling of Trains and Shuttles in the Channel Tunnel

Laurent Daudet, PhD Student, Ecole des Ponts Paris Tech, 6,8 av. Blaise Pascal, Marne-la-Vallée, 77455, France, laurent.daudet@cermics.enpc.fr, Frédéric Meunier

Facing a continuous growth of demand, Eurotunnel wishes to increase the capacity of the Tunnel without modifying the current infrastructures. In collaboration with this company, we propose optimization problems modeling this objective. We mainly focus on the problem of finding the shuttles departure times that minimize the longest waiting time. The motivation is to minimize the congestion in the terminals. Roughly speaking, the input is the forecasted demand, the number of shuttles, their capacity, and the loading speed. If both directions are assumed to be independent, we prove this problem to be polynomial. Otherwise, we get a nonlinear integer program which is approached via Lagrangian heuristics. The preliminary results are promising.

3 - Capacitated Facility Location with Assignment Connectivity and Distance Requirements

Kai Hennig, Zuse Institute Berlin, Takustr. 7, Berlin, Germany, hennig@zib.de

We consider a generalization of the Capacitated Facility Location problem where the assignments of each client are given as a set of nested paths in an undirected graph. Assignment connectivity requires that chosen assignments containing a common edge terminate at the same open facility node. Furthermore, we demand that predefined percentages of clients are assigned to facilities within given maximum distances. The task is to minimize the sum of facility opening and assignment realization cost. This kind of problem arises, for example, when designing profitable Fiber-To-The-Curb networks using VDSL2-Vectoring technology. We investigate structural properties of the problem, introduce MIP formulations, and present computational results.

■ MF11

11- Brigade

Enhancing Branch-and-Bound Type Methods

Cluster: Combinatorial Optimization

Invited Session

Chair: Marcus Poggi, PUC-Rio Informatica, R. M.S. Vicente 225, Rio de Janeiro, Brazil, poggi@inf.puc-rio.br

1 - Alpha-Critical Constraints for the Stable Set IP

Craig Larson, Associate Professor, Mathematics, Virginia Commonwealth University, 4106 Grace E. Harris Hall, 1015 Floyd Ave, Richmond, VA, 23284-2014, United States of America, clarson@vcu.edu

The independence (or stability) number of a graph is the cardinality of a maximum set of non-adjacent vertices. Useful cutting planes for the corresponding IP are given by clique and odd-hole constraints. An alpha-critical graph is one where the removal of any edge increases the independence number of the graph; these include cliques and odd-holes. Many other alpha-critical graphs exist besides cliques and odd-holes. We discuss experiments with a variety of alpha-critical graph constraints, and present new theoretical results.

2 - Benders Decomposition Based Hybrid Approach for the Coil Allocation and Retrieval Problem

Yuan Yuan, Institute of Industrial Engineering & Logistics Optimization, Northeastern University, Shenyang, 110819, China, yyuan.tli@gmail.com, Lixin Tang

The coil allocation and retrieval problem is to allocate coils to orders and also to schedule the retrieval of the allocated coils. We model the problem considering the constraints of the practical technological requirements and the special stacking structure of coils in the warehouses. To solve the problem, we propose a hybrid approach combining Benders decomposition and branch-and-cut where Benders decomposition acts as the main framework and employs branch-and-cut to handle its integer subproblem. Various valid inequalities are developed by exploiting the problem structure to accelerate the solution process.

3 - The Minimum Spanning Forest with Balance Constraints Problem (MSFBC)

Marcus Poggi, PUC-Rio Informatica, R. M.S. Vicente 225, Rio de Janeiro, Brazil, poggi@inf.puc-rio.br, Ian Herszterg, Thibaut Vidal

The MSFBC considers a graph where edges have nonnegative costs and vertices have weights either one or minus one. We seek for a minimum cost spanning forest where in each tree the vertices' total weight is zero. Branch-and-cut and branch-and-price algorithms are devised. Speed-ups are obtained by variable fixing based on bounds from a dual ascent procedure and primal heuristics. Experiments are carried over instances from the application of the MSFBC to the 2D-Phase Unwrapping Problem (2DPU) in the L 0-Norm, where discontinuities of the wrapped phase image (residues) are associated to the vertices that have either positive or negative polarity. Possible improvements with a branch-cut-and-price algorithm are discussed.

■ MF13

13- Rivers

Semidefinite Programming and Polynomial Optimization I

Cluster: Conic Programming

Invited Session

Chair: Cordian Riener, Aalto University, Aalto, Helsinki, Finland, Cordian.Riener@aalto.fi

1 - Gram Spectrahedra

Cynthia Vinzant, North Carolina State University, Department of Mathematics, Raleigh, NC, United States of America, cynthia.vinzant@gmail.com, Daniel Plaumann, Rainer Sinn, Emmanuel Tsukerman

Many problems in polynomial optimization can be approximated using sums of squares relaxations, which can be solved efficiently via semidefinite programming. The collection of sums of squares representations of a given polynomial is a slice of the cone of positive semidefinite matrices called a Gram spectrahedron. I will talk about the interesting convex and algebraic structure of these spectrahedra and some consequences for sums of squares optimization.

2 - Symmetry Reduction for Sums of Squares on the Hypercube

Greg Blekherman, Georgia Tech, 686 Cherry Street, Atlanta, GA, United States of America, greg@math.gatech.edu

Let p be a symmetric polynomial, i.e. a polynomial fixed under permutations of variables, and let H be the discrete hypercube {0,1}^n. The question of whether p is a sum of squares of polynomials of low degree on H can be reduced to a univariate sum of squares problem. I will present this reduction and explain how some known results on the Lasserre sum of squares hierarchy on H easily follow from it.

3 - A Semidefinite Hierarchy for Disjointly Constrained Bilinear Programming

Kai Kellner, Goethe University, Germany, kellner@math.uni-frankfurt.de

Bilinear programming concerns the problem of maximizing a bilinear function over the product of two polyhedra. While maximizing a linear function (linear programming) is known to be solvable in polynomial time, bilinear programming is NP-hard. Based on a reformulation of the problem in terms of sum-of-squares polynomials, we study a hierarchy of semidefinite relaxations to the problem. As our main result, we show that the semidefinite hierarchy converges generically in finitely many steps to the optimal value of the bilinear problem.

■ MF14

14- Traders

Network Economics

Cluster: Game Theory

Invited Session

Chair: Azarakhsh Malekian, Assistant Professor, University of Toronto, 105 saint George, toronto, On, M4Y 3G4, Canada, azarakhshm@gmail.com

1 - Privacy-Aware Network Formation: Triadic Closure and Homophily

Azarakhsh Malekian, Assistant Professor, University of Toronto, 105 Saint George, Toronto, On, M4Y 3G4, Canada, azarakhshm@gmail.com, Daron Acemoglu, Ali Makhdoumi, Asu Özdaglar

We consider a network formation game in which agents must collectively form a network in the face of the following trade-off: each agent receives benefits from the direct interactions she forms to others, but these links expose her to the risk of her information leaking to others unintentionally. We formulate the problem in terms of strategic network formation, and study the properties of its Nash equilibrium. We establish that this model explains triadic closure and high clustering that are common features of many real-world networks. We further show the emergence of clustered networks in the presence of homophily.

2 - Intermediation and Voluntary Exposure to Counterparty Risk

Maryam Farboodi, Princeton Univeristy, 11 East Merwick Court, Princeton, NJ, 08540, United States of America, farboodi@princeton.edu

I develop a model of the financial sector in which endogenous intermediation among debt financed banks generates excessive systemic risk. Financial institutions have incentives to capture intermediation spreads through strategic borrowing and lending decisions. By doing so, they tilt the division of surplus along an intermediation chain in their favor, while at the same time reducing aggregate surplus. A core-periphery network - few highly interconnected and many sparsely connected banks - endogenously emerges in my model. The equilibrium network is inefficient since banks who make risky investments "overconnect", exposing themselves to excessive counterparty risk, while banks who mainly provide funding end up with too few connections.

3 - Spread of Epidemics on Random Graphs: A Modified Bass Model for Product Growth in Networks

Vahideh Manshadi, Assistant Professor, Yale School of Management, 165 Whitney Ave, New Haven, United States of America, vahideh.manshadi@yale.edu, Ramesh Johari, Sidhant Misra

Many products and innovations become widespread through the social interaction of individuals in a population. Bass model has been widely used to model the temporal evolution of the adoption in such social systems. Bass model implicitly assumes a global interaction among all individuals in the network. Such global interactions, however, do not exists in many large social networks. To quantify the growth rate in networks with limited interactions, we study the evolution of a simple epidemic model on random k-regular graphs. We analyze the adoption timing for k-regular random graphs and present the limit results for the time it takes for a fraction of the population to adopt. Further, we provide the timing of early adoptions at finer scales.

■ MF15

15- Chartiers

Implementations and Software

Cluster: Implementations and Software

Invited Session

Chair: Jesús VelasquezMathematical Programming Entrepreneur - CEO and Chief Scientist, DecisionWare International Corp., Finca la Antigua, Tabio, Bogotá, Cu, Colombia, jesus.velasquez@decisionware.net

1 - A Numerical Comparative Study of Steepest Descent Methods for Strongly Convex Quadratic Minimization

Mituhiro Fukuda, Tokyo Institute of Technology, 2-12-1-W8-41 Oh-okayama, Meguro-ku, Tokyo, 152-8552, Japan, mituhiro@is.titech.ac.jp, Kensuke Gotoh

We have investigated the behaviors of various step-sizes utilized in the steepest descent method for different patterns of eigenvalue distributions of the strongly convex quadratic function coefficient matrices. As one can expect, some strategies are advantageous than others and they depend on the eigenvalue distribution. We also compared with the conjugate gradient method for general trends.

2 - Optex Mathematical Modeling System: The Meta-Framework for Mathematical Programming

Jesús Velasquez, Mathematical Programming Entrepreneur - CEO and Chief Scientist, DecisionWare International Corp., Finca la Antigua, Tabio, Bogota, Cu, Colombia, jesus.velasquez@decisionware.net, Andrés Insuasty

What Optimization technology should I choose? Use OPTEX MATHEMATICAL MODELING SYSTEM that includes all of them in just one algebraic formulation. OPTEX separates the algebraic formulation of the source code of any language programming and generates mathematical models in C or in other modeling language like GAMS, IBM-OPL, MOSEL, AIMMS, AMPL – OPTEX supports every stage of mathematical modeling process; data model definition and validation, algebraic model definition (with its own unique database algebraic language), numerical model generation, problem solution (with third party solvers) and results visualization (with third party software). Due to its relational data base nature, OPTEX generates SQL statements to connect any DBMS.

■ MF16

16- Sterlings 1

News in High Performance MIP and MINLP Software

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

1 - Recent Advances in CPLEX for Mixed Integer Nonlinear Optimization

Pierre Bonami, CPLEX Optimization, IBM Spain, Sta. Hortensia 26-28, Madrid, Spain, pierre.bonami@es.ibm.com

We present some of the new algorithmic techniques that have been recently added to the IBM CPLEX solver. We focus in particular on mixed integer second order cone programming and quadratic optimization. We present extensive computational analysis to assess the performance gain compared to previous CPLEX versions.

2 - Recent Developments in BARON

Mustafa Kilinc, Postdoctoral Researcher, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, mkilinc@andrew.cmu.edu, Nikolaos Sahinidis

We report recent developments in the integer arsenal of branch-and-reduce and their implementation in the global optimization software BARON. In addition to convex nonlinear and linear programming, usage of mixed-integer and piecewise linear programming provides a portfolio of relaxations aimed to provide tight relaxations for global optimization problems. New features include more aggressive preprocessing, probing, bound tightening from duals, and new tree management techniques. Specific cutting plane generation now produces knapsack cover, knapsack with GUB cover, clique, implication, and flow cuts. Extensive computational results will be presented on problems from a collection of test sets.

3 - Presolving Methods for MIQCQP and MISOCP in the Xpress Optimizer

Pietro Belotti, Xpress Optimizer Team, FICO, Starley Way, Birmingham, United Kingdom, pietrobelotti@fico.com

We discuss some techniques used in the FICO Xpress Optimizer 7.9 to reduce bounds, eliminate variables, and otherwise reduce the complexity of mixed integer quadratically constrained and conic optimization problems. While some techniques are only useful at root presolve, other techniques are fast and can be used at any BB node. We present computational results on a large set of instances to show the impact of the presolver in these problems.

■ MF17

17- Sterlings 2

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: Olga Brezhneva, Associate Professor, Miami University, 123 Bachelor Hall, Department of Mathematics, Oxford, OH, 45056, United States of America, brezhnoa@miamioh.edu

1 - Variable Sample Line Search Method for Distributed Optimization

Natasa Krklec Jerinkic, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovica 4, Novi Sad, 21000, Serbia-Montenegro, natasa.krklec@dmi.uns.ac.rs, Natasa Krejic, Dragana Bajovic, Dusan Jakovetic

We consider optimization problems related to structures with a large number of nodes where each of them aims to minimize its local cost function while the overall cost (sum of the nodes' local costs) is controlled by the fusion center. In order to decrease the overall optimization cost, algorithm performs line search iteration only with an information from the subset (sample) of nodes. The subset is governed by the parameter which represents the probability of activating each node. The probability parameter is related to the measure of progress in the objective function. Eventually, the whole set is activated almost surely providing the solution of the same quality as the one obtained by taking the whole sample from the start.

2 - Riemannian Newton's Method for Optimization Problems on the Stiefel Manifold

Hiroyuki Sato, Assistant Professor, Tokyo University of Science, 1-3, Kagurazaka, Shinjuku-ku, Tokyo, 1628601, Japan, hsato@ms.kagu.tus.ac.jp, Kensuke Aihara

Riemannian Newton's equation for an optimization problem on the Stiefel manifold, which is equivalent to the truncated singular value decomposition, is difficult to solve in its original form. In this talk, we rewrite the Newton's equation into a large sparse symmetric linear system. We also consider matrix-free Krylov subspace methods for solving the linear system. Numerical experiments show the effectiveness of our proposed method.

3 - KKT-type Optimality Conditions for Nonregular Optimization Problems

Olga Brezhneva, Associate Professor, Miami University, 123 Bachelor Hall, Department of Mathematics, Oxford, OH, 45056, United States of America, brezhnoa@miamioh.edu, Alexey Tret'yakov

The focus of this talk is on optimization problems with inequality constraints. We are interested in the case when classical regularity assumptions (constraint qualifications) are not satisfied at a solution. We start with discussion of constraint qualifications that imply the Karush-Kuhn-Tucker (KKT) optimality conditions. Then we propose new constraint qualifications and present generalized KKT-type optimality conditions for nonregular optimization problems. The results are illustrated by some examples.

■ MF18

18- Sterlings 3

Stochastic Optimization in Energy Systems

Cluster: Stochastic Optimization

Invited Session

Chair: David Morton, Professor, Northwestern University, IEMS Department, 2145 Sheridan Road, Evanston, Il, 60208, United States of America, morton@mail.utexas.edu

1 - Computing Feasible Solutions in Dual Decomposition Method Applied to Stochastic Integer Programming

Kibaek Kim, Aronne National Laboratory, 9700 South Cass Avenue, Argonne, IL, 60439, United States of America, kimk@anl.gov, Victor Zavala

The dual decomposition method can be used to obtain good lower bounds for stochastic mixed integer programs. The method, however, cannot guarantee to recover feasible solutions unless the problem has (relatively) complete recourse. We present algorithmic enhancements to effectively recover feasible solutions and to obtain upper bounds. Numerical results are provided on benchmark and unit commitment instances.

2 - Stochastic Dynamic Programming Models for Co-Optimizing Storage Operations

Ramteen Sioshansi, Associate Professor, The Ohio State University, 240 Baker Systems, 1971 Neil Avenue, Columbus, OH, 43210, United States of America, sioshansi.1@osu.edu

Energy storage, especially distributed storage, has the potential to provide many grid-related services. This inherent flexibility makes storage operations planning a challenging optimization problem. This talk introduces a stochastic dynamic programming model that co-optimizes the use of distributed storage to provide multiple services. An approximation algorithm that can efficiently find near-optimal decision policies is also presented. An illustrative case study and results are also given.

3 - Optimal Microgrid Design under Load and Photovoltaic Uncertainty

Alexander Zolan, PhD Student, Department of Operations Research and Industrial Engineering, University of Texas at Austin, 204 E. Dean Keeton Street, Stop C2200, ETC 5.160, Austin, TX, 78757, United States of America, alex.zolan@utexas.edu, Alexandra Newman, David Morton

We present a model for establishing the design and energy dispatch for a microgrid that minimizes cost and fuel requirements given a set of available technologies (diesel generators, solar arrays and batteries) and the probability model that governs the photovoltaic power availability on location and load profile at a forward operating base. We introduce a policy-based restriction of the problem that allows for the tractable solution of a multiple scenario problem while preserving solution quality.

■ MF19

19- Ft. Pitt

Theory and Applications of Multi-Objective Optimization

Cluster: Multi-Objective Optimization

Invited Session

Chair: Matthias Ehrgott, Professor and Head of Department, Lancaster University, Bailrigg, Lancaster, 00, LA1 4YX, United Kingdom, m.ehrgott@lancaster.ac.uk

1 - Stability Aspects for the Maxcut Problem with Multiple Criteria

Yury Nikulin, University of Turku, Finland, Assistentinkatu 7, 20014 Turku, Finland, yurnik@utu.fi, Kiril Kuzmin

We consider a multiple criteria version of the maxcut problem with uncertain input data. The stability is understood as some property of invariance for the set of efficient (Pareto optimal) solutions (cuts). We obtain analytical formulae of the qualitative measures of stability, the so-called stability radii, and scrutinize their properties. Computational complexity is also discussed. It is shown that, even in a single criterion case, the problem of finding exact values of the radius with any stability property cannot be solved polynomially unless P=NP.

2 - Optimisation over the Non-Dominated Set of a Multi-Objective Linear Programme

Matthias Ehrgott, Professor and Head of Department, Lancaster University, Bailrigg, Lancaster, 00, LA1 4YX, United Kingdom, m.ehrgott@lancaster.ac.uk, Zhengliang Liu

We present two new algorithms for the maximisation of a linear function over the non-dominated set of a multi-objective linear programme (MOLP). The algorithms are based on primal and dual variants of Benson's outer approximation algorithm to solve MOLPs in objective space. We compare the new algorithms with algorithms from the literature on a set of randomly generated instances. The results show that the new algorithms outperform the existing ones. As a special case, we consider the adaptation of our algorithms for the computation of the nadir point of an MOLP which is given by the worst values over the non-dominated set. We numerically compare the algorithms with a known exact algorithm from the literature to show their superiority.

3 - Finding Representations of the Nondomoniated Set in Multiobjective Optimization

Serpil Sayin, Koc University, Rumeli Feneri Yolu, Sariyer, Istanbul, 34450, Turkey, ssayin@ku.edu.tr, Gokhan Kirlik

One way to solve multiobjective optimization problems is by obtaining a representation which is a finite discrete subset of the true nondominated set. Ideally, the representation should meet a quality specification given by the decision maker. We present an algorithm for generating a representation that meets a specified coverage error. The algorithm partitions the outcome space into subsets and solves a bilevel programming subproblem for each partition element. The subproblem either finds a nondominated solution in the partition or reports that no such solution exists. Partitions are refined accordingly. We demonstrate the algorithm on a multiobjective linear programming problem using rectangular partition elements.

■ MF20

20- Smithfield

Nonsmooth Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Vinay Singh, Assistant Professor, National Institute of Technology, Department of Mathematics, NIT Mizoram, Chaltlang, Aizawl-796012 M, Aizawl, 796012, India, vinaybhu1981@gmail.com

1 - Accelerated L-BFGS for Large Scale Nonsmooth Convex Optimization

Lorenzo Stella, PhD Student, IMT Institute for Advanced Studies Lucca, Piazza San Francesco 19, Lucca, Italy, lorenzo.stella@imtlucca.it, Panagiotis Patrinos

We propose L-BFGS algorithms for nonsmooth convex composite optimization problems. These rely on the concept of forward-backward envelope (FBE), a smooth function whose unconstrained minimizers are solutions to the original problem. The complexity per iteration of our algorithms is similar to the one of the proximal gradient method, which makes them suitable for large scale applications. We show that the proposed algorithms enjoy the optimal convergence rate of FISTA, but are much faster in practice.

2 - An SQP-Inspired Algorithm for Nonsmooth Nonconvex Optimization

Hermann Schichl, A.Professor, University of Vienna, Oskar-Morgenstern-Platz 1, Vienna, 1090, Austria, hermann.schichl@univie.ac.at, Hannes Fendl, Arnold Neumaier

This talk will be about the first step on a roadmap towards an algorithm for solving general nonsmooth nonconvex programs. Taking inspiration from the SQP-method for smooth optimization we develop a strictly feasible second order bundle method for minimizing a nonsmooth objective function with respect to nonsmooth inequality constraints. The search direction is determined by solving a convex quadratically constrained quadratic program to obtain good iteration points. Furthermore, global convergence of the method is proved under certain mild assumptions. For an implementation numerical results will be presented, as well as an application to certificates of infeasibility and exclusion boxes for numerical constraint satisfaction problems.

3 - On Constraint Qualifications in Nonsmooth Mathematical Programs with Vanishing Constraints

Vinay Singh, Assistant Professor, National Institute of Technology, Department of Mathematics, NIT Mizoram, Chaltlang, Aizawl-796012 M, Aizawl, 796012, India, vinaybhu1981@gmail.com, Vivek Laha, S. K. Mishra

This paper studies mathematical programs with vanishing constraints (MPVC) under the assumptions of differentiability or Lipschitz continuity. We derive nonsmooth Karush-Kuhn-Tucker (KKT) type necessary optimality conditions for the MPVC in terms of Michel-Penot (M-P) subdifferentials. Several modifications of some known constraint qualifications like Abadie constraint qualification, Cottle constraint qualification, Slater constraint qualification, Mangasarian-Fromovitz constraint qualification and linear independence constraint qualification for the MPVC have also been studied.

■ MF21

21-Birmingham

Recent Advances in Derivative-Free Optimization II: Software and Applications

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Zaikun Zhang, Dr., CERFACS-IRIT Joint Lab, CERFACS, 42 Avenue Gaspard Coriolis, Toulouse, 31057, France, zaikun.zhang@irit.fr

1 - Derivative-Free Optimization Methods for a Surface Structure Inverse Problem

Juan C. Meza, Prof., University of California, Merced, 5200 N. Lake Road, Merced, Ca, 95343, United States of America, jcmeza@ucmerced.edu

We will describe the use of pattern search methods and simplified physics surrogates for determining the surface structure of nanosystems. Pattern search methods have the ability to handle both continuous and categorical variables, which arises in the optimization of the coordinates and chemical identity of atoms on surfaces. We demonstrate these methods on an inverse problem arising from the simulation of nanostructures using the low energy electron diffraction (LEED) method for simulating material properties.

2 - Derivative-Free Bilevel Optimization in Road Design

Yves Lucet, Associate Professor, University of British Columbia, ASC 350, Computer Science unit 5, 3187 University Way, Kelowna, BC, V1V 1V7, Canada, yves.lucet@ubc.ca, Sukanto Mondal, Warren Hare

We split the road design problem (building the cheapest road that satisfies safety and regulation constraints) in 2 subproblems: the horizontal alignment (computing a satellite view of the road), and the vertical alignment and earthwork (determining where to cut or fill material and deciding what material to move where). We report numerical results on using derivative-free optimization to compute the horizontal alignment and a mixed-integer linear program to compute the vertical alignment and earthwork.

3 - GC-ES: A Globally Convergent Evolution Strategy for Unconstrained and Constrained Optimization

Youssef Diouane, Dr., CERFACS, 42 av. Garspard Coriolis, Toulouse Cedex 01, 31057, France, youssef.diouane@cerfacs.fr, Serge Gratton, Luis Nunes Vicente

We present a new DFO software for unconstrained and constrained optimization problems. The proposed software equips an evolution strategy (ES) with known techniques from deterministic DFO. The modified ES achieves rigorously a form of global convergence. Using feasible approaches, the software is extended to handle general constrained optimization problems. Our solver is compared to others, and the numerical results confirm its competitiveness in terms of efficiency and robustness.

MF22

22- Heinz

Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Christine Edman, University of Trier, Department of Mathematics, Trier, 54286, Germany, edman@uni-trier.de

1 - A Pull System's Inventory Model with Carbon Tax Policy

Tien-Yu Lin, Dr., Overseas Chinese University, 100, Chiao Kwang Rd., Taichung, 40721, Taiwan - ROC, admtyl@ocu.edu.tw

This paper aims at developing a new inventory model with carbon tax policy and imperfect quality items in which buyer has exerted power over its supplier. Four considerations are included in this new model. Moreover, this paper employs the order overlapping scheme to rectify a flaw appeared in Lin's (2010) and Chang's (2011) works. An efficient algorithm is then developed to find the optimal solution. This paper further investigated the effects of different carbon tax mechanisms on the optimal solution. Numerical examples are available in this paper to illustrate the proposed model and algorithm. Managerial insights are also explored.

2 - A Global Optimization Method for a Quadratic Reverse Convex Programming Problem by Listing FJ Points

Syuuji Yamada, Dr., Niigata University, 8050 Ikarashi 2-no-cho, Nishi-ku, Niigata, 9502181, Japan, yamada@math.sc.niigata-u.ac.jp

In this talk, we consider a quadratic reverse convex programming problem (QRC) whose feasible set is expressed as the area excluded the interior of a convex set from another convex set. It is known that many global optimization problems can be transformed into such a problem. One of the difficulties for solving (QRC) is that all locally optimal solutions do not always satisfy KKT conditions. In order to overcome this drawback, we introduce a procedure for listing FJ points of (QRC). Further, we propose an algorithm for finding a globally optimal solution of (QRC) by incorporating such a procedure into a branch and bound procedure.

3 - Solution Methods for Black-Box Optimization Problems

Christine Edman, University of Trier, Department of Mathematics, Trier, 54286, Germany, edman@uni-trier.de, Mirjam Dür

We consider expensive optimization problems, that is, problems, where each evaluation of the objective function is expensive in terms of computation time, consumption of ressources, or costs. This happens in situations where the objective is not available in analytic form, but evaluations are the result of a simulation. Therefore it is important to use as few evaluation points as possible. We discuss response surface methods which use a sophisticated strategy to determine evaluation points.

MF23

23- Allegheny

Adjustable and Nonlinear Robust Optimization

Cluster: Robust Optimization

Invited Session

Chair: Dick den Hertog, Tilburg University, P.O. Box 90153, Tilburg, Netherlands, D.denHertog@uvt.nl

1 - Robust Optimization of Uncertain Multistage Inventory Systems with Inexact Data in Decision Rules

Frans de Ruiter, Tilburg university, Warandelaan 2, Tilburg, Netherlands, f.j.c.t.deruiter@uvt.nl, Ruud Brekelmans, Dick den Hertog, Aharon Ben-Tal

Adjustable Robust Optimization (ARO) is a method to solve multistage decision problems. In this paper we show that ARO models may show poor performance if the revealed data is of poor quality. We remedy this weakness of ARO by introducing a methodology that treats past data itself as an uncertain model parameter. Our methods maintain the computational tractability of ARO models. The benefits of our new approach are demonstrated on a well-known production-inventory problem.

2 - When are Static and Adjustable Robust Optimization Equivalent?

Ahmadreza Marandi, Tilburg University, Haseltstraat 282, Tilburg, 5041MB, Netherlands, a.marandi@uvt.nl, Dick den Hertog

Adjustable Robust Optimization (ARO) yields, in general, better worst-case solutions than static Robust Optimization (RO). However, ARO is computationally more difficult than RO. We derive conditions under which the worst-case objective values of ARO and RO problems with constraint-wise uncertainty are equal. Additionally, we show that omitting one of the assumptions can make the worst-case objective values different. Furthermore, we extend these results to problems that also contain uncertain parameters that are not constraint-wise.

3 - Solving Robust Nonlinear Optimization Problems via the Dual

Dick den Hertog, Tilburg University, P.O. BOX 90153, Tilburg, Netherlands, D.denHertog@uvt.nl, Bram Gorissen

We show how to solve a robust nonlinear (convex-concave) optimization problem by explicitly deriving its dual. Given an optimal solution of this dual, we show how to recover the primal optimal solution. The fascinating and appealing property of our approach is that any convex uncertainty set can be used. We obtain computationally tractable robust counterparts for many new robust nonlinear optimization problems, including problems with robust quadratic constraints, second order cone constraints, and SOS-convex polynomials.

MF24

24- Benedum

Optimization and Variational Problems with Applications I

Cluster: Multi-Objective Optimization

Invited Session

Chair: Akhtar Khan, Associate Professor, Rochester Institute of Technology, Center for Applied and Comp. Math., School of Mathematical Sciences, Rochester, NY, 14623, United States of America, aaksma@rit.edu

Co-Chair: Baasansuren Jadamba, Rochester Institute of Technology, School of Mathematical Sciences, Rochester, NY, 14623, United States of America, bxjsma@rit.edu

1 - A Generalized Mean Value Inequality with Applications to Dynamic Optimization

Robert Kipka, Queen's University, Department of Math & Stats, Jeffery Hall, University Ave., Kingston, ON, K7L 3N6, Canada, robert.kipka@queensu.ca, Yuri Ledyaev

In this talk we introduce a multi-directional mean value inequality which includes variations originating in topological vector spaces. Examples of dynamic optimization problems in which topological vector spaces play an important role and some applications of this inequality will be given.

2 - Minimization of a Principal Eigenvalue of a Mixed Dispersal Model

Baasansuren Jadamba, Rochester Institute of Technology, School of Mathematical Sciences, Rochester, NY, 14623, United States of America, bxjsma@rit.edu

We consider an indefinite weight linear eigenvalue problem of a mixed dispersal model. The model describes organisms that disperse locally and non-locally. We investigate the minimization of the positive principal eigenvalue under the constraint that the weight is bounded from above and below, and the total weight is a fixed negative constant.

MF25

25- Board Room

Disease Surveillance

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Nedialko Dimitrov, The University of Texas at Austin, 1 University Station, Engineering Teaching Center 5., Austin, TX, 78712, United States of America, ned@austin.utexas.edu

1 - Optimal Data Source Selection in Disease Surveillance Networks

Ravi Srinivasan, Research Fellow, The University of Texas at Austin, Dept. of Statistics and Data Sciences, 1 University Station G2500, Austin, TX, 78712, United States of America, rav@math.utexas.edu

We present several methods for selecting data sources to best satisfy a given surveillance objective. In particular, we focus on the use of readily available online data streams for situational awareness and early detection of seasonal influenza. A comparison of these methods and their relative advantages and disadvantages is also provided.

2 - Designing Multifaceted Dengue Surveillance Systems

Samuel Scarpino, Santa Fe Insitute, 1399 Hyde Park Road, Santa Fe, NM, 87501, United States of America, scarpino@santafe.edu, Lauren Meyers, Michael Johansson

Surveillance systems are often shaped by historical, logistical, and economic constraints rather than optimized to address specific objectives. Here, we advance the systematic optimization developed by Scarpino, Dimitrov, & Meyers (2012) to evaluate and improve dengue surveillance in Puerto Rico with respect to three objectives: real-time estimation of island-wide incidence, regional incidence, and viral serotype incidence. Using data from 1991 to 2005, we identified subsets of clinics that efficiently achieved these objectives independently and in combination. We then compared these surveillance systems to systems designed using alternative methods. Finally, we assessed the robustness of this optimized system with data from 2006 to 2012.

3 - Fast, Approximate Inference on Graphical Models with Almost Independent Nodes

Areesh Mittal, Graduate Student, University of Texas at Austin, 2900 Cole Street, # 209, Austin, TX, 78705, United States of America, areesh0612@gmail.com, Nedialko Dimitrov

In some graphical models, distant nodes have little influence on each other. We show that this property, called almost independence, allows us to perform fast, approximate inference by reducing the size of the graph. We demonstrate results on discrete and Gaussian graphical models. One application of our fast, approximate inference methods is intelligence collection on a social network, where nodes are people and intercepted communications provide information on a person's suspicious activity level.

■ MF26

26- Forbes Room

Stochastic Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: John Siirola, Sandia National Laboratories, P.O. Box 5800, MS 1326, Albuquerque, NM, 87185, United States of America, jdsiiro@sandia.gov

1 - Monitoring and Accelerating Progressive Hedging with Cross-scenario Information

John Siirola, Sandia National Laboratories, P.O. Box 5800, MS 1326, Albuquerque, NM, 87185, United States of America, jdsiiro@sandia.gov, David L. Woodruff, Jean-Paul Watson

Progressive Hedging (PH) is a scalable and effective approach for solving large stochastic programming problems through scenario-based decomposition. However, PH is sensitive to the selection of key tuning parameters (notably rho) and for many real-world problems can exhibit slow convergence. In this work we present new approaches for accelerating convergence and improved tuning of PH by propagating key information among the scenarios. This includes cross-scenario feasibility cuts, tracking overall lower and upper objective bounds, and new heuristics for automatically determining appropriate rho values.

2 - Distributionally Robust Two-Stage Stochastic Linear Programming with a WKS-Type of Ambiguity Set

Bin Li, Curtin University, Department of Mathematics and Statistics, Australia, bin.li@curtin.edu.au, Jie Sun, Kok Lay Teo, Changjun Yu

In this paper, we consider a distributionally robust version of a two-stage stochastic linear program that incorporates the worst-case recourse function over a set of possible probability distributions. Other than analyzing these new models case by case for different ambiguity sets, we generalize the different ambiguity sets into a unified framework proposed by Wiessmann, Khun and Sim, and extend their analysis from a single constraint to two-stage stochastic linear programming.

3 - A Note on Complexity of Multistage Stochastic Programs

Marcus Reaiche, IMPA, Estrada Dona Castorina, 110, Rio de Janeiro, RJ, 22460-320, Brazil, mmcr@impa.br

In Shapiro [2006], estimates of the sample sizes required to solve a multistage stochastic programming problem with a given accuracy by the conditional sample average approximation method were derived. In this presentation we construct an example in the multistage setting that shows that these estimates cannot be significantly improved.

■ MF27

27- Duquesne Room

Coping with Dynamics and Uncertainty in Energy Systems

Cluster: Optimization in Energy Systems

Invited Session

Chair: Daniel Kuhn, EPFL, EPFL-CDM-MTEI-RAO, Station 5, Lausanne, Switzerland, daniel.kuhn@epfl.ch

Co-Chair: Andy Sun, Assistant Professor, Georgia Institute of Technology, 765 Ferst Drive, Room 444 Groseclose Bld., Atlanta, GA, 30332, United States of America, andy.sun@isye.gatech.edu

1 - A Multi-Scale Decision Rule Approach for Multi-Market Multi-Reservoir Management

Napat Rujeerapaiboon, École Polytechnique Fédérale de Lausanne, EPFL CDM MTEI RAO, ODY 1 19, Station 5, Lausanne, 1015, Switzerland, napat.rujeerapaiboon@epfl.ch, Daniel Kuhn, Wolfram Wiesemann

Peak/off-peak spreads on European electricity spot markets are eroding due to the nuclear phaseout and the recent growth in photovoltaic capacity. The reduced profitability of peak/off-peak arbitrage thus forces hydropower producers to participate in the balancing markets. We propose a two-layer stochastic programming model for the optimal operation of a cascade of hydropower plants selling energy on both spot and balancing markets. The master problem optimizes the reservoir management over a yearly horizon with weekly granularity, and the slave problems optimize the market transactions over a weekly horizon with hourly granularity. We solve both the master and slave problems in linear decision rules to achieve computational tractability.

2 - Multistage Adaptive Robust Optimization for the Unit Commitment Problem

Alvaro Lorca, Georgia Institute of Technology, 755 Ferst Drive NW, Atlanta, GA, United States of America, alvarolorca@gatech.edu, Eugene Litvinov, Tongxin Zheng, Andy Sun

Motivated by the increasing penetration of wind and solar power generation in power systems, we present a multistage adaptive robust optimization model for the unit commitment problem, considering uncertainty in nodal net electricity loads. The proposed model takes into account the time causality of the hourly unfolding of nodal net loads. To deal with large-scale systems, we explore the idea of simplified affine policies and develop a solution method based on constraint generation. Computational experiments demonstrate that the proposed algorithm is effective in handling large-scale power systems and that the proposed model can outperform both deterministic and two-stage models.

3 - Connections between Least Squares Monte Carlo and Math Programming Based ADP

Selvaprabu Nadarajah, Assistant Professor of Operations Management, College of Business, University of Illinois at Chicago, 601 South Morgan Street, Chicago, IL, 60607, United States of America, selvan@uic.edu, Nicola Secomandi

Least squares Monte Carlo (LSM) methods are popular in financial engineering, including energy real option applications, while math programming ADP methods are widespread in operations research. We connect recent LSM and math programming ADP methods using an approximate linear programming (ALP) relaxation approach. This research provides a new perspective on LSM, insights into existing ALP relaxations, and motivates methodological extensions. We also discuss numerical results comparing these methods on an energy real option application.

■ MF28

28- Liberty Room

Complementarity/Variational Inequality II

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Michael Hintermüller, Prof., Humboldt-Universitaet zu Berlin, Room 2.426 (House 2, 4th floor), Rudower Chaussee 25, Berlin, 12489, Germany, hint@math.hu-berlin.de

1 - Non-Smooth Cahn-Hilliard / Navier-Stokes Problems

Michael Hintermüller, Prof., Humboldt-Universitaet zu Berlin, Room 2.426 (House 2, 4th floor), Rudower Chaussee 25, Berlin, 12489, Germany, hint@math.hu-berlin.de

Phase separation phenomena modelled by the Cahn-Hilliard (CH) system with an obstacle potential, leading to a class of complementarity problems, are considered. For modelling two-phase flows, this system is further coupled with the Navier-Stokes (NS) equations. Besides semi-smooth Newton solvers based on adaptive methods for CH/NS, optimization problems with CH/NS as constraints are discussed analytically as well as numerically.

2 - Analysis and Numerics of Optimization Problems with Variational Inequality Constraints

Thomas Surowiec, Humboldt-Universitaet zu Berlin, surowiec@math.hu-berlin.de

We present new techniques for the sensitivity analysis of variational inequalities of the second-kind. These results lead to the derivation of stationarity conditions similar to what is known for mathematical programs with complementarity constraints. Furthermore, the sensitivity results allow us to develop new types of numerical methods that do not require us to smooth the original optimization problem. The strength of the methods are illustrated by several examples.

3 - Extra-Gradient Method with Reduced Variance for Pseudo-Monotone Stochastic Variational Inequalities

Philip Thompson, IMPA and CMM, Estrada Dona Castorina, 110, Rio de Janeiro, RJ, 22460-320, Brazil, philipthomp@gmail.com, Roberto Oliveira, Alfredo Iusem, Alejandro Jofre

We give an extra-gradient method with constant stepsize for pseudo-monotone stochastic variational inequalities. We prove a.s. convergence and show the sequence is bounded in Lp. We allow an unbounded set and a non-uniform error variance with no regularization. Under the above assumptions, we achieve an accelerated rate with near-optimal complexity in terms of the natural residual. The estimates depend on the distance from initial points to the solution set (with sharper constants in case the variance is uniform). In a second part, we present incremental one-projection methods under monotonicity. The first variant requires weak-sharpness. The second uses a regularization procedure with partial step-size coordination in a multi-agent system.

■ MF29

29- Commonwealth 1

Operator Splitting Methods and Alternating Direction Method of Multipliers

Cluster: Nonsmooth Optimization

Invited Session

Chair: Shiqian Ma, Assistant Professor, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, William M.W.Mong Engineering Building, Shatin, N.T., Hong Kong - PRC, sqma@cuhk.edu.hk

Co-Chair: Shuzhong Zhang, Professor, University of Minnesota, Department of Industrial and Systems Eng, Minneapolis, MN, 55455, United States of America, zhangs@umn.edu

1 - A New Operator Splitting Scheme and its Applications

Wotao Yin, Professor, University of California, Los Angeles, Box 951555, 520 Portola Plz, MS 7620B, Los Angeles, CA, 90095, United States of America, wotaoyin@math.ucla.edu, Damek Davis

We introduce a new operator-splitting scheme for solving monotone inclusion and optimization problems of 3 blocks. The scheme includes the existing forward-backward, Douglas-Rachford, and forward-Douglas-Rachford splitting schemes as its special cases. The new scheme reduces problems into a series simpler steps. It easily applies to (split) feasibility problems, nonnegative SDPs, color image inpainting via tensor completion, 3-block monotropic programs, and so on. The scheme solves monotone inclusions: 0 in (A+B+C)x, where A and B are (single or set-valued) monotone operators and C is a cocoercive operator, with guaranteed convergence and rate.

2 - Convergence Analysis of Alternating Direction Method of Multipliers for a Family of Nonconvex Problems

Mingyi Hong, Iowa State University, 3015 Black Engineering, Ames, IA, 50011, United States of America, mingyi@iastate.edu

The alternating direction method of multipliers (ADMM) is widely used to solve large-scale linearly constrained optimization problems, convex or nonconvex, in many engineering fields. However there is a general lack of theoretical understanding of t he algorithm when the objective function is nonconvex. In this paper we analyze the convergence of the ADMM for solving certain nonconvex consensus and sharing problems, and show that the classical ADMM converges to the set of stationary solutions, provided that the penalty parameter in the augmented Lagrangian is chosen to be sufficiently large. For the sharing problems, we show that the ADMM is convergent regardless of the number of variable blocks.

3 - On Convergence Rate of ADMM and Its Variants for Convex Optimization with Coupled Objectives

Xiang Gao, PhD Candidate, University of Minnesota, Shepherd Lab 485, 111 Church Street SE, Minneapolis, MN, 55455, United States of America, gaoxx460@umn.edu, Shuzhong Zhang

In this talk we shall discuss the ADMM (Alternating Direction Method of Multipliers) and its variants to solve multi-block convex optimization where the objective function involves a term coupling all the variables. We show that under mild conditions the ADMM and its variants are guaranteed to converge at a rate of O(1/N), where N stands for the number of iterations.

■ MF30

30- Commonwealth 2

Approximation and Online Algorithms IV

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Hyung-Chan An, EPFL, EPFL IC IIF THL2, Station 14, Lausanne, 1015, Switzerland, hyung-chan.an@epfl.ch

1 - Approximation Algorithms for the Redundancy-Aware Facility Location Problem

Chaoxu Tong, Cornell University, 296 Rhodes Hall, 136 Hoy Road, Ithaca, NY, 14853, United States of America, blackchaoxu@gmail.com, David Shmoys, Chaitanya Swamy

We consider Redundancy Aware Facility Location problem, an extension of classical facility location.Each client has a set of sevices on demand and we need to assign every client to a facility with all requiredservices installed. The goal is to minimize the total service installation cost and clients routing cost. Wecome up with a noval dual ascent schema and extend the classical Jain-Vazirani primal dual algorithmto the special case where the demand sets of all clients form a laminar family. Combining with othertechniques, we obtain the current best approximation guarantee for this problem.

2 - An Improved Approximation for k-median, and Positive Correlation in Budgeted Optimization

Khoa Trinh, University of Maryland, A.V. Williams, College Park, MD, 20782, United States of America, khoa@cs.umd.edu, Jaroslaw Byrka, Bartosz Rybicki, Thomas Pensyl, Aravind Srinivasan

Dependent rounding is a useful technique for optimization problems with hard budget constraints. We develop algorithms that guarantee the known properties of dependent rounding, but also have nearly best-possible behavior — near-independence, which generalizes positive correlation — on “small” subsets of the variables. We improve upon Li-Svensson’s approximation ratio for k-median from $2.732 + \epsilon$ to $2.611 + \epsilon$ by developing an algorithm that improves upon various aspects of their work. Our dependent-rounding approach helps us improve the dependence of the runtime on the parameter ϵ from Li-Svensson’s $N^{O(1/\epsilon^2)}$ to $N^{O((1/\epsilon) \log(1/\epsilon))}$.

3 - Dynamic Facility Location via Exponential Clocks

Hyung-Chan An, EPFL, EPFL IC IIF THL2, Station 14, Lausanne, 1015, Switzerland, hyung-chan.an@epfl.ch, Ashkan Norouzi-Fard, Ola Svensson

We present a new LP-rounding algorithm for facility location problems, which yields the first constant approximation algorithm for the dynamic facility location problem. This problem is a generalization of the classic facility location problem, proposed by Eisenstat, Mathieu, and Schabanel to model the dynamics of evolving social/infrastructure networks. Our algorithm is based on competing exponential clocks and exhibits several properties that distinguish our approach from previous LP-roundings for facility location problems. In particular, we use no clustering and we allow clients to connect through paths of arbitrary lengths. We demonstrate that these properties enable us to apply our new algorithm to the dynamic problem.

Tuesday, 9:00am - 9:50am

■ TA01

01- Grand 1

Optimization in the Age of Big Data

Cluster: Plenary

Invited Session

Chair: Javier Pena, Professor of Operations Research, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, jfp@andrew.cmu.edu

1 - Optimization in the Age of Big Data Sparsity and Robustness at Scale

Laurent El Ghaoui, Professor, University of California, Berkeley, 421 Sutardja Dai Hall, Berkeley, CA, United States of America, elghaoui@berkeley.edu

The term "big data" is too often associated with the sole task of applying machine learning analytics to large data sets. It seems that optimization has been concerned with large data sets for a long time already, not just as purveyor of algorithms for analytics but also as models for decision-making. What is changing in the interface between learning and decision-making? What is the impact of big data on optimization? I will present various approaches and perspectives stemming from the application of optimization models in a big data context. The talk will focus on sparsity and robustness, both in statistical learning and decision-making problems. Some case studies involving online retail problems, finance and energy resource management will be presented. The emerging picture is that of an ever closer integration between the two fields, at both practical and fundamental levels.

Tuesday, 10:20am - 11:50am

■ TB01

01- Grand 1

Nonsmooth Analysis and Applications

Cluster: Variational Analysis

Invited Session

Chair: Alejandro Jofre, Professor, Universidad de Chile/Center Mathematical Modeling, Beauchef 851, edificio Norte, 7mo piso, Santiago, Santiago, Chile, ajofre@dim.uchile.cl

1 - Integration and Approximate Subdifferentials Calculus for Nonconvex Functions

Rafael Correa, Profesor, Center for Mathematical Modeling, Beauchef 850 Piso 7, Santiago de Chile, 852000, Chile, rcorrea@dim.uchile.cl, Yboon Garcia, Abderrahim Hantoute

We present three integration theorems of the epsilon subdifferential of nonconvex functions in locally convex spaces. We prove that an inclusion relationship between the epsilon subdifferentials of two any functions yet yields the equality of the closed convex envelopes up to an additive constant. When this relation only involves small values of epsilon, the integration criterion as well as the conlcusion of the integration theorems also take into account the behaviour at infinity of the functions.

2 - On the Subdifferential of Convex Integrals

Abderrahim Hantoute, Dr, Center for Mathematical Modeling, Beauchef 850 Piso 7, Santiago de Chile, 852000, Chile, ahantoute@dim.uchile.cl, Abderrahim Jourani, Rafael Correa

We provide new characterizations for the subdifferential of convex integrals whose normal integrand are defined in locally convex Suslin spaces. This setting is very convenient since it includes, from one hand, the most important settings for many applications, and, on the other hand, allows the use of the machinery of integration of vector- valued functions and multi-functions. These characterizations are given by means of the approximate subdifferential of the involved functions, and do not require any qualiffcation conditions. As a result, in the Banach setting we recover some recent results due to L. Thibaut - O. López and to A. Ioffe.

■ TB02

02- Grand 2

Intermittent Resources and Demand Response I

Cluster: Optimization in Energy Systems

Invited Session

Chair: Alfredo Garcia, Professor, Department of Industrial and Systems Engineering, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611-6595, United States of America, alfredo.garcia@ufl.edu

1 - Personalized Pricing for Demand Response

Alfredo Garcia, Professor, Department of Industrial and Systems Engineering, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611-6595, United States of America, alfredo.garcia@ufl.edu

In order to encourage consumers to reduce consumption and/or to alter their consumption patterns, most demand response programs rely on offering a menu of incentive contracts. Designing these contracts is a difficult task as consumers differ widely in their ability and willingness to shift and/or reduce electricity consumption over time. We present an iterative pricing mechanism which is guaranteed to implement (in dominant strategies) an efficient inter-temporal consumption profile.

2 - Mechanism Design for Pricing in Electricity Markets

Benjamin Heymann, Ecole Polytechnique, Route de Saclay, Palaiseau, France, benjamin.heymann@polytechnique.edu, Alejandro Jofre

We consider an incomplete information wholesale electricity market model. We derive an optimal regulation mechanism, and compare its performance to an auction setting, for which we numerically compute the Nash equilibrium, prove the theoretical convergence of the algorithm and explore the structure of the equilibrium strategies. We extend the results to the more general case.

3 - Decentralized Efficient PEV Charging Coordination

Ian Hiskens, Professor, University of Michigan, 1301 Beal Avenue, Ann Arbor, MI, 48109, United States of America, hiskens@umich.edu

Coordinated charging of large numbers of plug-in electric vehicles (PEVs) will be considered. The formulation of interest seeks to capture the tradeoffs inherent in delivering maximum energy at minimum cost, over a fixed time horizon, whilst ensuring the charge rate (power) remains reasonable. A decentralized algorithm will be presented. This process consists of PEVs determining the charge profile that minimizes their cost relative to a prespecified price curve. The aggregator collects these charge profiles and determines an updated price curve which is rebroadcast to all PEVs. The process then repeats. It will be shown that this procedure converges to the unique, efficient (socially optimal) solution.

■ TB03

03- Grand 3

Large-Scale Transportation Networks

Cluster: Combinatorial Optimization

Invited Session

Chair: Sebastian Stiller, TU Berlin, Strasse des 17. Juni 136, Berlin, 10623, Germany, sebastian.stiller@tu-berlin.de

1 - Solving Train Timetabling Problems by Combining Configuration Networks and Ordering Constraints

Frank Fischer, Dr., University of Kassel, Heinrich-Plett-Str. 40, Kassel, 34132, Germany, frank.fischer@mathematik.uni-kassel.de

Given an infrastructure network and a set of trains with predefined routes, the train timetabling problem asks for conflict free schedules of those trains such that capacity restrictions in the stations and on the tracks are satisfied. One popular modelling approach is based on time expanded networks. We present an extension that strengthens the associated models by combining the configuration networks modelling technique with additional ordering constraints that allow including further combinatorial properties of the network into the model. Finally, we present promising computational results that demonstrate the superior effect of the new approach.

2 - The Block Plan Visualization Problem

Boris Grimm, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, grimm@zib.de, Thomas Schlechte, Markus Reuther

The Block Plan Visualization Problem (BPVP) is a sub problem arising during the optimization process of a large scale Rolling Stock Rotation Problem (RSRP). This is done in cooperation with DB Fernverkehr the biggest German railway company. The BPVP is the linking step between the RSRP solution, i.e., a set of cycles and its practical operation. Its task is to group elements of cycles into equally sized blocks while minimizing an objective function. This can be seen as a quadratic assignment problem. We compare heuristic and exact approaches based on Mixed Integer Linear Programming to tackle the problem. Finally, we provide computational results for real world data scenarios.

3 - Strategic Planning in Large-Scale Logistic Networks

Alexander Richter, Technische Universitaet Berlin, Institut für Mathematik, Sekr. MA 5-1, Strafle des 17. Juni 136, Berlin, 10623, Germany, arichter@math.tu-berlin.de, Sebastian Stiller

We consider hub networks from the perspective of a logistics' customer using different freight forwarders to serve its demands between several sources and sinks. We devise a robust optimization method for hub rental and routing under involved, realistic cost. Arc cost depend on the maximum demand in multiple properties. Such strategic decisions are made before actual demand is known. We seek robust solutions with lowest cost under a restricted worst-case of fluctuating demands. Using budgeted interval uncertainty, we derive a carefully relaxed MILP suitable for large instances due to its strong LP-relaxation. Results on real-world data show that robust optimization significantly reduces worst-case cost, while keeping historic average cost.

■ TB04

04- Grand 4

Computational Issues in Semidefinite Programming

Cluster: Conic Programming

Invited Session

Chair: Henry Wolkowicz, Professor, University of Waterloo, Faculty of Mathematics, Waterloo, ON, N2L3G1, Canada, hwolkowi@uwaterloo.ca

1 - Singularity Degree in Semi-definite Programming

Dmitriy Drusvyatskiy, Professor, University of Washington, Box 354350, Seattle, 98195, United States of America, ddrusv@uw.edu, Nathan Krislock, Gabor Pataki, Yuen-Lam Voronin, Henry Wolkowicz

Degenerate semi-definite programs — those without a strictly feasible point —- often arise in applications. The singularity degree of an SDP, introduced by Sturm, is an elegant complexity measure of such degeneracies. I will revisit this notion and its relationship to basic concepts, such as nonexposed faces of conic images, facial reduction iterations, and error bounds. Matrix completion problems will illustrate the ideas.

2 - Computational Aspects of Finding Lyapunov Certificates for Polynomial System via SOS Relaxation

Yuen-Lam Voronin, Dr, University of Colorado, Boulder, CO, United States of America, Yuen-Lam.Voronin@colorado.edu, Sriram Sankaranarayanan

We consider the problem of finding polynomial Lyapunov functions that certify the stability of polynomial systems. Using SOS relaxation, we often arrive at large scale semidefinite (SDP) feasibility problem instances even for polynomial systems with only modest amount of variables. We discuss some numerical difficulties that arise when solving those SDP instances. We explore several strategies for efficiently and accurately solving the SDP relaxation for finding polynomial Lyapunov functions: (1) understanding the linear maps associated with the SOS-Lyapunov stability, (2) facial reduction techniques for regularization, if necessary, and (3) specialized solution methods for finding polynomial Lyapunov certificates.

3 - Conic Optimization over Nonnegative Univariate Polynomials

Mohammad Ranjbar, PhD Student, Rugers University, 100 Rockafeller RD, New Brunswick, NJ, 08854, United States of America, 59ranjbar@gmail.com, Farid Alizadeh

We consider the conic optimization problem over nonnegative univariate polynomials and the dual moment cone; both polynomials nonnegative on an interval and on the real line are considered. It is well-known that such optimization problems can be reduced to semidefinite programming. However, this transformation may require squaring the number of variables. In addition, working with polynomials in the standard basis is notoriously ill-conditioned. We propose dual algorithms which express polynomials in the numerically stable basis of Chebyshev polynomials, and reduce cost of forming the Schur complement in interior point methods by using Fast Fourier Transform and other techniques. Concrete numerical results will be presented.

■ TB05

05- Kings Garden 1

Methods and Applications of Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Michael Ulbrich, Professor, TU Muenchen, Dept. of Mathematics, Boltzmannstr. 3, Garching, 85747, Germany, mulbrich@ma.tum.de

1 - A Derivative-Free Method for Nonlinear Optimization Problems with Deterministic Noise

Andreas Waechter, Northwestern University, 2145 Sheridan Road, Room E280, Evanston, IL, 60208, United States of America, waechter@iems.northwestern.edu, Alvaro Maggiar, Irina Dolinskaya

We present a new derivative-free method to optimize functions that are subject to numerical noise. The algorithm smoothes the objective using a Gaussian kernel, and computes a local model by regression for a trust-region step. The method employs Monte-Carlo approximations where multiple importance sampling makes it possible to reuse objective function evaluations across optimization iterates. Numerical results on a set of test problems will be presented.

2 - Efficient Inexact Strategies for Subproblem Solutions in QP, NLP, and LCP

Daniel P. Robinson, Assistant Professor, Johns Hopkins Univeristy, 3400 N. Charles Street, 100 Whitehead Hall, Office 202B, Baltimore, MD, 21218-2682, United States of America, daniel.p.robinson@jhu.edu, Frank E. Curtis

Active-set methods for quadratic problems (QP), nonlinear problems (NLP), and complementarity problems (CP) aim to identify the constraints that are active at a solution. In the large-scale case, iterative method such as linear or nonlinear CG are often used to optimize over a "face", i.e., a subspace formed by forcing certain inequality constraints to hold as equalities. It is important to design computational conditions that reliably and quickly identify when the active-set estimate is incorrect, and moreover how to proceed. A great example of this is the work by Dostal and Schoberl for minimizing a strictly convex QP subject to bound-constraints. In this talk, I consider related ideas for nonconvex QPs, NLPs, and asymmetric LCPS.

3 - A Proximal Gradient Method for Ensemble Density Functional Theory

Michael Ulbrich, Professor, TU Muenchen, Dept. of Mathematics, Boltzmannstr. 3, Garching, 85747, Germany, mulbrich@ma.tum.de, Chao Yang, Dennis Kloeckner, Zaiwen Wen, Zhaosong Lu

The ensemble density functional theory for electronic structure calculations (especially metallic systems) yields a nonconvex optimization problem with a matrix variable and orthogonality constraints. Extensions of the widely used self-consistent field (SCF) iteration to this problem exist, but their convergence theory is limited. We consider an equivalent model involving a spectral function (entropy) that has one matrix variable and a single spherical constraint. A proximal gradient method is developed by keeping the entropy term and linearizing the remaining energy terms. Convergence to stationary points is established. Numerical results in the KSSOLV toolbox show that the new method can outperform SCF on many metallic systems.

■ TB06

06- Kings Garden 2

Network Design

Cluster: Telecommunications and Networks

Invited Session

Chair: Eli Olinick, Associate Professor, SMU, P.O. Box 750123, Dallas, TX, 75275, United States of America, olinick@lyle.smu.edu

1 - Compact Formulation of Multicommodity Flow with Applications to Telecommunications Network Design

Eli Olinick, Associate Professor, SMU, P.O. Box 750123, Dallas, TX, 75275, United States of America, olinick@lyle.smu.edu

We present a new formulation of multicommodity flow inspired by the old adage that ``every journey starts with a first step". That is, flow on a non-trivial path between i and j must pass through a node k adjacent to i, and then be adjoined to the flow from k to j. The flow variable for node triple (i, j, k) represents the sum of path flows over all paths that include a subpath from i to j with edge {i, k} as the first edge. This characterization of flow yields a more compact formulation allowing more efficient solutions including instances either too large or too time consuming to solve by the standard edge-path and node-edge formulations. We present an empirical study applying our new formulation of the network design problem.

2 - Dynamic Inequalities for Capacitated Survivable Network Design

Richard Chen, Principal Member of Technical Staff, Sandia National Laboratories, Quantitative Modeling & Analysis Dept, Sandia National Labs, 7011 East Avenue, Livermore, United States of America, rlchen@sandia.gov, Cynthia Phillips

We consider a capacitated survivable network design problem that requires a feasible multicommodity flow to exist after any k edge failures. Existing approaches generate violated inequalities based on a fixed (static) failure scenario. We present new valid inequalities that dynamically cover all failure scenarios pertaining to a given network vulnerability. We then present a branch-column-cut algorithm and empirical studies on SNDlib and randomly generated instances to demonstrate the effectiveness of dynamic inequalities.

3 - Multi-Source Multi-Commodity Capacitated Facility Location Problem (cFLP) with Dynamic Demands

Dimitri Papadimitriou, Alcatel-Lucent, Copernicuslaan 50, 2018, Antwerp, 2018, Belgium, dimitri.papadimitriou@alcatel-lucent.com, Piet Demeester

The dynamic content replication and placement problem generalizes the cFLP to multiple commodities as various content objects of different size may be available at different locations. Demands dynamics may lead to consider replication of content objects at multiple locations and assignments other than the closest facility depending on the capacity allocation model and associated constraints. Topology dynamics may also induce changes in the distance between clients and facilities which imposes to include as part of the objective function the cost of rerouting when clients change their connected facilities. In this paper, we compare different formulations and resolution methods for the resulting problem together with numerical experiments.

■ TB07

07- Kings Garden 3

Computational Linear Programming I

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Stephen Maher, Zuse Institute Berlin, Takustr. 7, Berlin, Germany, maher@zib.de

1 - Symmetry in Linear Programming

Roland Wunderling, IBM, Annenstrasse 9, Graz, 8020, Austria, roland.wunderling@at.ibm.com, Jean-Francois Puget

Symmetry has long been identified as a problem for Mixed Integer Programming solvers, because it can cause a combinatorial explosion of the tree by exploring symmetric areas of the search space. Consequently, techniques have been developed to avoid such combinatorial explosion. In contrast, Linear Programming does not suffer such combinatorial explosion, and hence the effect of symmetry is expected to be much less severe. In this presentation we quantitatively explore how much symmetry affects LP and if performance improvements can be gained from exploiting symmetry.

2 - SoPlex: A New Exact LP Solver

Ambros Gleixner, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, gleixner@zib.de, Daniel Steffy, Kati Wolter

We present the underlying theory and the implementational aspects of SoPlex's new algorithms for solving linear programs exactly over the rational numbers: a high-level iterative refinement strategy, a rational LU factorization, and an output-sensitive reconstruction routine for rounding approximate solution candidates to exact solutions with bounded denominators. Our computational study shows major performance improvements over the state-of-the-art. The implementation is publically available in source code and on the NEOS server for optimization.

3 - Initial Basis Selection for LP Crossover

Christopher Maes, Gurobi Optimization Inc., 125 Beacon St. #4, Boston, MA, 02116, United States of America, maes@gurobi.com

Singular and ill-conditioned bases arise frequently when crossing over from an interior solution of a linear program. These ill-conditioned bases can slow the crossover algorithm and even cause it to fail. The sparsity and condition of later bases, and the total number of crossover steps, is influenced by the choice of the initial basis. The ideal initial basis is sparse, well-conditioned, and has few artificial variables. However, these properties often conflict with one another. We present a sparse LU factorization and ordering algorithm for selecting an initial basis that balances these different factors. We compare this new method to the approach used in version 5 of the Gurobi Optimizer on a test set of linear programming problems.

■ TB08

08- Kings Garden 4

Approximation Algorithms for Network Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Rico Zenklusen, ETH Zurich, Ramistrasse 101, HG G 21.3, Zurich, 8092, Switzerland, ricoz@math.ethz.ch

1 - Improved Region-Growing and Combinatorial Algorithms for k-Route Cut Problems

Laura Sanitá, University of Waterloo, 200 University Ave W, Waterloo, Canada, laura.sanita@uwaterloo.ca, Chaitanya Swamy, Guru Guruganesh

We study the k-route generalizations of various cut problems, the most general of which is k-route multicut, wherein we have r source-sink pairs and the goal is to delete a minimum-cost set of edges to reduce the edge-connectivity of every pair to below k. We present various approximation and hardness results that improve the state-of-the-art for these problems in several cases. Our algorithms are based on combinatorial techniques and on a new powerful region-growing approach.

2 - On Approximating Storage Allocation Problems as Good as Their Siblings

Andreas Wiese, MPI for Informatics, Campus E 1.4, Saarbruecken, 66123, Germany, awiese@mpi-inf.mpg.de, Jatin Batra, Tobias Moemke

Three particularly important and well-studied packing problems are the Unsplittable Flow on a Path problem (UFP), the Maximum Weight Independent Set of Rectangles problem (MWISR), and the 2-dimensional geometric knapsack problem. We study the storage allocation problem (SAP) which is a natural combination of those three problems. We present a (2+epsilon)-approximation algorithm for SAP and additionally a quasi-PTAS if the edge capacities can be increased by an arbitrarily small factor. Also, we construct a PTAS for the dynamic storage allocation problem (DSA) in an resource-augmentation setting where we are allowed to reject an epsilon-fraction of the input task, according to an arbitrary weight function.

3 - Online Network Design Algorithms via Hierarchical Decompositions

Seeun William Umboh, University of Wisconsin-Madison, 1210 W. Dayton St., Madison, WI, 53706, United States of America, seeun@cs.wisc.edu

We develop a new approach for network design, and apply it to obtain optimal (up to constants) competitive ratios for several online optimization problems. At the heart of this work is an analysis framework based on embeddings into hierarchically well-separated trees (HSTs): we show that the cost of the algorithm can be charged to the cost of the optimal solution on any HST embedding of the terminals. Unlike the usual algorithmic application of tree embeddings, the embeddings are used only for the analysis, not in the algorithm. Our approach yields simple greedy algorithms and straightforward analyses for the online Steiner network with edge duplication, rent-or-buy, connected facility location and prize-collecting Steiner forest problems.

■ TB09

09- Kings Garden 5

Exact Methods for Mixed-Integer Optimization Problems with Uncertainties

Cluster: Combinatorial Optimization

Invited Session

Chair: Frauke LiersProf., Friedrich-Alexander Universitaet Erlangen-Nürnberg, Department Mathematik, Cauerstrasse 11, Erlangen, Germany, frauke.liers@math.uni-erlangen.de

1 - A Frank-Wolfe Based Branch-and-Bound Algorithm for Mean-Risk Portfolio Optimization Problems

Marianna De Santis, TU Dortmund, Vogelpothsweg 87, 44227, Dortmund, Germany, marianna.de.santis@math.tu-dortmund.de, Long Trieu, Francesco Rinaldi, Christoph Buchheim

A commonly used model for portfolio optimization problems is the so called "risk-averse capital budgeting problem". In this talk, we propose a generalized version of this model, that leads to a convex mixed-integer nonlinear programming problem. The continuous relaxation of the problem is solved by a properly designed Frank-Wolfe type algorithm, that is then inserted into a branch-and-bound scheme. Experimental results on real-world instances are presented.

2 - Solving Mixed-Integer Semidefinite Programs for Robust Truss Topology Design

Tristan Gally, TU Darmstadt, Department of Mathematics, Dolivostr. 15, Darmstadt, 64293, Germany, gally@mathematik.tu-darmstadt.de, Marc Pfetsch

In this talk we will describe techniques for solving mixed-integer semidefinite programs coming from robust truss topology design with a branch-and-bound algorithm. We will deal with binary variables arising from choosing bars out of a discrete set for a given ground structure. The goal is to create a stable truss of minimal volume. We discuss general techniques like dual fixing and problem specific methods, e.g. heuristics and branching rules.

3 - Robust Time-Window Assignment for Runway Utilization

Frauke Liers, Prof., Friedrich-Alexander Universitaet Erlangen-Nürnberg, Department Mathematik, Cauerstrasse 11, Erlangen, Germany, frauke.liers@math.uni-erlangen.de, Andreas Heidt, Manu Kapolke, Alexander Martin

Efficient planning of runway utilization is one of the main challenges in Air Traffic Management. We develop an optimization approach for the pre-tactical planning phase in which time windows are assigned to aircraft. Mathematically, this leads to a b-matching problem with side constraints. In reality, uncertainty and inaccuracy almost always lead to deviations from the actual schedule. We present several robust optimization approaches together with computational results that show their effectiveness.

■ TB10

10- Kings Terrace

Advances in Quantification of Financial Data, Distributions, and Risk

Cluster: Finance and Economics

Invited Session

Chair: Jörgen Blomvall, Associate Professor, Linköping University, Linköping 58183, Sweden, jorgen.blomvall@liu.se

1 - High Quality Measurement of Financial Market Data

Jörgen Blomvall, Associate Professor, Linköping University, Linköping, 58183, Sweden, jorgen.blomvall@liu.se

High quality measurement of financial properties such as interest rate curves and volatility surfaces from market data is challenging due to noise, yet crucial to e.g. avoid arbitrage in investment models. The central choice is the choice of decision variables which impact the convexity and the regularization of the inverse problem. Both aspects can be very important for the resulting quality of the measurement, as will be illustrated with examples from the interest rate and option markets.

2 - Simultaneous Default Intensity Estimation from Bonds by a Generalized Optimization-based Framework

Johan Gustafsson, Linköpings universitet, IEI, Linköping, 581 83, Sweden, johan.gustafsson@liu.se, Jörgen Blomvall

The estimation of default intensity curves from corporate bonds is complicated by the fact that market data contain noise arising from e.g. illiquidity and indicative prices. This difficulty is addressed by estimating the default intensity curves for different credit risks simultaneously through modelling the relations between them in a generalized optimization-based framework. Results from a cross-section of Swedish and US companies are compared with results from traditional models. Preliminary results from a time series study are also presented.

3 - Optimal Expectation Inequalities for Structured Distributions

Bart Van Parys, PhD, ETH Zurich, Physikstrasse 3, Zurich, Switzerland, bartvan@ethz.ch

Quantifying the risk of unfortunate events occurring, despite limited distributional information, is a problem underlying many practical questions. Indeed, quantifying violation probabilities in distributionally robust programming or judging the risk of financial positions can be seen to involve risk quantification. We discuss worst-case probability and conditional value-at-risk problems, where the information is limited to second-order moment information and structural information such as unimodality and monotonicity. We indicate how exact and tractable reformulations can be obtained using tools from Choquet and duality theory. We make our results concrete with a stock portfolio pricing problem and a financial risk aggregation case study.

■ TB11

11- Brigade

Paths

Cluster: Combinatorial Optimization

Invited Session

Chair: Marco Blanco, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, blanco@zib.de

1 - On a Shortest 2-Path Problem

Haotian Song, University of Calgary, 2500 University Drive NW, Calgary, AB, T2N1N4, Canada, hasong@ucalgary.ca, Yuriy Zinchenko

An electric power supplier needs to build a transmission line between 2 jurisdictions. Ideally, the design of the new electric power line would be such that it maximizes some user-defined utility function, for example, minimizes the construction cost or the environmental impact. Due to reliability considerations, the power line developer has to install not just one, but two transmission lines, separated by a certain distance from one-another, so that even if one of the lines fails, the end user will still receive electricity along the second line. We discuss how such a problem can be modeled, and in particular, demonstrate a setting that allows to solve this problem in polynomial time.

2 - Solving the Quadratic Shortest Path Problem

Borzou Rostami, Technische Universitaet Dortmund, Vogelpothsweg 87, Dortmund, 44227, Germany, brostami@mathematik.tu-dortmund.de, Emiliano Traversi, Christoph Buchheim

This talk addresses the Quadratic Shortest Path problem (QSPP). We prove strong NP-hardness of the problem and analyze polynomially solvable special cases, obtained by restricting the distance of arc pairs in the graph that appear jointly in a quadratic monomial of the objective function. Based on these special cases we compute separable quadratic global underestimators of the objective function to compute a lower bound and embed the bounding procedure into a Branch-and-ound framework.

3 - The Course Constrained Shortest Path Problem

Marco Blanco, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, blanco@zib.de, Ralf Borndoerfer, Nam Dung Hoang, Thomas Schlechte

The Course Constrained Shortest Path Problem arises as a major challenge in flight trajectory optimization. It consists of computing a shortest s,t-path on a graph, subject to restrictions defined by CNF boolean formulas on the node and arc variables. We present polyhedral results for the special case of the Path Avoiding Forbidden Pairs Problem. We also introduce novel solution algorithms for the general case, and test them on real-world instances.

■ TB12 10:30am - 11:00am

12- Black Diamond

AMPL – New Developments in the AMPL Modeling Language

Cluster: Software Presentations

Invited Session

Chair: David Gay, AMPL Optimization, Inc., 900 Sierra Place SE, Albuquerque, NM, 87108-3379, United States of America, dmg@ampl.com

1 - AMPL – New Developments in the AMPL Modeling Language

David Gay, AMPL Optimization, Inc., 900 Sierra Place SE, Albuquerque, NM, 87108-3379, United States of America, dmg@ampl.com, Victor Zverovich

We describe a recently developed AMPL API that provides seamless access to the AMPL modeling system from popular general-purpose programming languages, which may help you to embed optimization models in your applications. We also discuss various solver-interface issues that are to be documented in an updated “Hooking Your Solver to AMPL”, and we introduce new AMPL interfaces to Baron, LGO, and LocalSolver. Finally, we sketch some forthcoming AMPL features.

TB13

13- Rivers

Second-Order Cones, SDP and P-Norm Cones

Cluster: Conic Programming

Invited Session

Chair: Ellen Hidemi FukudaAssistant professor, Kyoto University, Sakyo-ku Yoshida Honmachi, Graduate School of Informatics, Kyoto, 606-8501, Japan, ellen@i.kyoto-u.ac.jp

1 - Novel Approach for Singly Constrained QCQP

Rujun Jiang, Chinese University of Hong Kong, C323,PGH1, Hong Kong, Hong Kong - PRC, rjjiang@se.cuhk.edu.hk, Duan Li

We investigate in this paper a general class of singly constrained quadratically constrained quadratic programming (QCQP) problem. We characterize all possible situations for the QCQP in the matrix sight, which, as to our knowledge, hasn't been done in the existing literature. Applying simultaneous block diagonalization, we obtain the congruent canonical form for both symmetric matrices in the objective function and in the constraint. We derive necessary conditions for the solvability of QCQP. For all solvable QCQP problems, we can transform them into their corresponding SOCP formulation. Compared to the state-of-the-art in formulating as semidefinite programming (SDP), our formulation delivers a much faster solution algorithm.

2 - Studies on Squared Slack Variables for Nonlinear Second-Order Cone and Semidefinite Programming

Ellen Hidemi Fukuda, Assistant professor, Kyoto University, Sakyo-ku Yoshida Honmachi, Graduate School of Informatics, Kyoto, 606-8501, Japan, ellen@i.kyoto-u.ac.jp, Masão Fukushima, Bruno Lourenco

The use of squared slack variables in nonlinear programming is well-known, but hardly considered in the optimization community. Usually, the advantage of having only equality constraints do not compensate for the disadvantages, like the increase of the dimension of the problem and the numerical instabilities. The situation is different for nonlinear second-order cone and nonlinear semidefinite programming cases. Since the reformulated problem has no longer conic constraints, we can solve the problem by using a general-purpose nonlinear programming solver. Here, we are concerned with the theoretical analysis of the squared slack variables approach, establishing the relation between KKT points of the original and the reformulated problems.

TB14

14- Traders

Resource Allocation Games with Structures

Cluster: Game Theory

Invited Session

Chair: Guido Schaefer, CWI, Science Park 123, Amsterdam, 1098XG, Netherlands, G.Schaefer@cwi.nl

1 - Price of Anarchy for Mechanisms with Admission

Bojana Kodric, MPI Informatik, Campus E 1 4, Saarbrücken, Germany, bojana@mpi-inf.mpg.de, Martin Hoefer, Thomas Kesselheim

We study repeated games with allocation mechanisms. In each round each mechanism is available for each player only with a certain probability. This is an elementary case of simple mechanism design with incomplete information, where availabilities are player types. It captures natural applications in online markets and for channel access in wireless networks. We propose an approach where each player uses a single no-regret learning algorithm and applies it independently of availability. This addresses some major concerns about learning outcomes in Bayesian settings. We show small bounds on the price of anarchy via novel composition theorems for smooth mechanisms, which rely on a new connection to the notion of correlation gap.

2 - Matroids are Immune to Braess Paradox

Tobias Harks, Maastricht University, Tongersetraat 53, Maastricht, Netherlands, t.harks@maastrichtuniversity.nl

The famous Braess paradox describes the following phenomenon: It might happen that the improvement of resources, like building a new street within a congested network, may in fact lead to larger costs for the players in an equilibrium. In this paper we consider general nonatomic congestion games and give a characterization of the maximal combinatorial property of strategy spaces for which Braess paradox does not occur. In a nutshell, bases of matroids are exactly this maximal structure. We prove our characterization by two novel sensitivity results for convex separable optimization problems over polymatroid base polyhedra which may be of independent interest. This is joint work with S. Fujishige, M.X. Goemans, B. Peis and R. Zenklusen.

3 - Coordination Games on Graphs

Mona Rahn, CWI, Science Park 123, Amsterdam, Netherlands, rahn@cwi.nl, Guido Schaefer, Krzysztof Apt, Sunil Simon

We introduce natural strategic games on graphs, which capture the idea of coordination in a local setting. We show that these games have an exact potential and have strong equilibria when the graph is a pseudoforest. We also exhibit some other classes of games for which a strong equilibrium exists. However, in general strong equilibria do not need to exist. Further, we study the (strong) price of stability and anarchy. Finally, we consider the problems of computing strong equilibria and of determining whether a joint strategy is a strong equilibrium. We also consider some extensions, in particular to weighted graphs.

TB15

15- Chartiers

Multilevel Algorithms for Large-Scale Optimisation

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Panos Parpas, Imperial College London, 180 Queens Gate, SW6 6DZ, London, United Kingdom, panos.parpas@imperial.ac.uk

1 - A Multilevel Approach for l1 Regularized Convex Optimization: Application to Covariance Selection

Eran Treister, Post-Doctoral Fellow, University of British Columbia, 408-3515 Wesbrook Mall, UBC,, Vancouver, BC, V6T1Z4, Canada, eran@cs.technion.ac.il, Irad Yavneh, Javier S. Turek

We present a multilevel framework for solving l1 regularized convex optimization problems, which are widely popular in the fields of signal processing and machine learning. Such l1 regularization is used to find sparse minimizers of the convex functions. The framework is applied for solving the Covariance Selection problem, where a sparse inverse covariance matrix is estimated from a only few samples of a multivariate normal distribution. Numerical experiments demonstrate the potential of this approach, especially for large-scale problems.

2 - Fast Multilevel Support Vector Machines

Talayeh Razzaghi, Postdoc, Clemson University, 100 McAdams Hall, Clemson, SC, 29634, United States of America, trazzag@g.clemson.edu, Ilya Safro

Solving optimization models (including parameters fitting) for support vector machines on large-scale data is often an expensive task. We propose a multilevel algorithmic framework that scales efficiently to very large data sets. Instead of solving the whole training set in one optimization process, the support vectors are obtained and gradually refined at multiple levels of data coarseness. Our multilevel framework substantially improves the computational time without loosing the quality of classifiers. The algorithms are demonstrated for both regular and weighted support vector machines for (im)balanced classification problems. Quality improvement on several imbalanced data sets has been observed.

3 - A Multilevel Proximal Algorithm for Large Scale Composite Convex Optimization

Panos Parpas, Imperial College London, 180 Queens Gate, SW6 6DZ, London, United Kingdom, panos.parpas@imperial.ac.uk

Composite convex optimization models consist of the minimization of the sum of a smooth convex function and a non-smooth convex function. Such models arise in many applications where, in addition to the composite nature of the objective function, a hierarchy of models is readily available. We adopt an optimization point of view and show how to take advantage of the availability of a hierarchy of models in a consistent manner. We do not use the low fidelity model just for the computation of promising starting points but also for the computation of search directions. We establish the convergence and convergence rate of the proposed algorithm and discuss numerical experiments.

■ TB16

16- Sterlings 1

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Jan Hackfeld, TU Berlin, Straße des 17. Juni 136, Berlin, 10623, Germany, hackfeld@math.tu-berlin.de

1 - Variable Sized Bucket Indexed Formulations for Nonpreemptive Single Machine Scheduling Problems

Hamish Waterer, University of Newcastle, University Dr, Callaghan, Australia, hamish.waterer@newcastle.edu.au, Riley Clement, Natashia Boland

The authors recently proposed a bucket indexed (BI) mixed integer linear programming formulation for nonpreemptive single machine scheduling problems. The BI model generalises the classical time (TI) indexed formulation to one in which at most two jobs can be processing in each period. The planning horizon is divided into periods of equal length, but unlike the TI model, the length of a period is a parameter of the model and can be chosen to be as long as the processing time of the shortest job. In this talk we present new BI formulations in which the lengths of each period are not required to be identical. Computational experiments comparing the performance of these models to those from the literature will be presented.

2 - The Complexity of the Matching Extension Problem in General Graphs

Jan Hackfeld, TU Berlin, Straße des 17. Juni 136, Berlin, 10623, Germany, hackfeld@math.tu-berlin.de, Arie M.C.A. Koster

A simple graph G with 2n vertices is said to be k-extendable for an integer k with 0 < k < n if G contains a perfect matching and every matching of cardinality k in G is a subset of some perfect matching. Lakhal and Litzler (1998) discovered a polynomial algorithm that decides whether a bipartite graph is k-extendable. For general graphs, however, it has been an open problem whether there exists a polynomial algorithm. In the talk, we will show that the extendability problem is coNP-complete. Moreover, we present an integer program together with a separation algorithm for the extendability problem.

3 - Extended Formulations for 2-D Cutting with 4-stage Restricted Guillotine and Rotation

Quentin Viaud, Université Bordeaux, Institut de Mathématiques, 351 cours de la Libération, IMB - B,t. A33, Talence, 33405, France, quentin.viaud@u-bordeaux.fr, Ruslan Sadykov, François Vanderbeck, François Clautiaux

We consider the two-dimensional bin packing problem where the cutting process is 4-stage and restricted to exact guillotine cuts, while piece rotation is allowed. For this NP-hard problem, combinatorial methods or compact MIP models are known to be weak. But so-called extended formulations can provide good approaches. The formulation we use is based on a hypergraph flow reformulation. We compare experimentally several methods (column generation, direct MIP approach) for solving efficiently this pseudo-polynomial-size model.

■ TB17

17- Sterlings 2

Numerical Methods for Structured Nonlinear Programs I

Cluster: Nonlinear Programming

Invited Session

Chair: Christian KirchesJunior Research Group Leader, TU Braunschweig / Heidelberg University, Im Neuenheimer Feld 368, Heidelberg, 69120, Germany, christian.kirches@iwr.uni-heidelberg.de

1 - Multilevel Iterations for Optimal Feedback Control

Ekaterina Kostina, University of Heidelberg, INF 293, Heidelberg, 69120, Germany, ekaterina.kostina@iwr.uni-heidelberg.de

We are interested in computing feedback optimal controls by simultaneous on-line MHE of the system states and parameters and re-optimization of the optimal control, as in NMPC. A bottleneck in practical applications is real time feasible implementation of the algorithm. One way to substantially reduce the response time are so-called multilevel iterations. However, today's state-of-the-art is to perform MHE and NMPC separately. A next logical step is the development of a simultaneous MHE and NMPC in one step. In this talk we present an efficient generalization of multilevel iterations based on coupling of the MHE and NMPC with inexact Newton methods which allows for further reduction of response times.

2 - An Elastic Active Set Approach for Large Structured QPs

Daniel Rose, Leibniz Universitaet Hannover, Welfengarten 1, Hannover, 30167, Germany, rose@ifam.uni-hannover.de, Marc C. Steinbach

We consider SQP methods for large structured QPs where a specialized sparse solver is available for the KKT system in an active set QP solver. Our goal is a generic active set algorithm that employs any custom KKT solver in a slack relaxation of the QP to avoid a phase 1. This involves a partial projection that preserves the NLP sparse structure in the KKT system. The talk discusses the structural properties of our approach and of the subproblems on several levels. As a concrete example we consider NLPs on trees arising, e.g., in robust model predictive control. We also discuss relevant aspects of the software design.

3 - Sequential Linear Equality Constrained Programming for Application in Mixed-Integer NMPC

Felix Lenders, Interdisciplinary Center for Scientific Computing, Heidelberg University, Im Neuenheimer Feld 368, Heidelberg, 69120, Germany, felix.lenders@iwr.uni-heidelberg.de, Christian Kirches, Georg Bock

In Mixed-Integer Model Predictive Control Applications similar Mathematical Programs with Equilibrium Constraints (MPEC) have to be solved. Methods for Nonlinear Programs as SQP may fail when applied to these problems. Sequential Linear Equality Constrained Programming (SLEQP) Methods are Active Set Methods using a Linear Program for active set determination. These methods can be extended towards MPEC and guarantee termination in Bouligand stationary points. In this talk a preliminary SLEQP Algorithm for MPEC will be presented.

■ TB18

18- Sterlings 3

Risk-Averse Stochastic Programming

Cluster: Stochastic Optimization

Invited Session

Chair: Guzin Bayraksan, Associate Professor, Ohio State University, 1971 Neil Ave., Columbus, OH, 43210, United States of America, bayraksan.1@osu.edu

1 - Distributionally Robust Stochastic Programs with Recourse with Variation Distance

Hamed Rahimian, The Ohio State University, 1971 Neil Ave., Columbus, OH, 43210, United States of America, rahimian.1@osu.edu, Guzin Bayraksan, Tito Homem-de-Mello

Traditional stochastic programs assume that data uncertainty is governed by a known probability distribution, and optimize the expected cost. When the probability distribution is unknown, an alternative modeling approach—-distributionally robust stochastic program—-hedges against the worst probability distribution in an ambiguity set. We focus on the variation distance to form the ambiguity set of distributions, and explore the properties of two-stage and multi-stage models. We propose a decomposition-based algorithm to obtain the optimal policy and the worst probability distribution. Finally, we characterize a minimal scenario tree, where the presence of every scenario is critical in determining the optimal objective function.

2 - Risk Aversion in Multistage Stochastic Programming: A Modeling and Algorithmic Perspective

Bernardo Pagnoncelli, Universidade Adolfo Ibanez, Diagonal las Torres 2640 oficina 533-C, Santiago, Chile, bernardo.pagnoncelli@uai.cl, Tito Homem-de-Mello

In this presentation I will discuss the incorporation of risk measures into multistage stochastic programs. Much attention has been recently devoted in the literature to this type of model, but there is no consensus on the best way to accomplish that goal. I will discuss pros and cons of the existing approaches, and propose a novel definition of consistency. A class of risk measures which we call expected conditional risk measures is discussed, and a pension fund example illustrates the use of this risk measure in practice.

3 - A Decomposition Method for Two-Stage Stochastic Programs with Risk-Averse Utilities

Tito Homem-de-Mello, Universidad Adolfo Ibanez, Diagonal las Torres 2640 Penalolen, Santiago, Chile, tito.hmello@uai.cl, Sebastian Arpon, Bernardo Pagnoncelli, Rodrigo Carrasco

We discuss a decomposition method for two-stage stochastic programs with risk-averse utilities. Our algorithm is based on the Alternating Direction Method of Multipliers (ADMM) developed in the literature, and decomposes the problem by scenarios. Some attractive features of the algorithm are its simplicity of implementation and its suitability for parallelization. We discuss some aspects related to convergence of the method and present results from numerical experiments to illustrate the ideas.

TB19

19- Ft. Pitt

Hybrid Optimization I

Cluster: Constraint Programming

Invited Session

Chair: Michele Lombardi, DISI, University of Bologna, Viale del Risorgimento 2, Bologna, 40136, Italy, michele.lombardi2@unibo.it

1 - Variable Branching in MIPs: A Machine Learning approach

Elias Khalil, Georgia Institute of Technology, 1062 Hemphill Avenue NW, Atlanta, GA, 30318, United States of America, lyes@gatech.edu, Bistra Dilkina, Le Song

A machine learning (ML) framework for variable branching in Mixed Integer Linear Programs is proposed. In phase I, our method observes the decisions made by Strong Branching (SB), an effective yet inefficient strategy, and collects features that characterize variables at each search tree node. Based on the collected data, we learn an easy-to-evaluate surrogate function to mimic SB by solving a “learning-to-rank” problem, common in ML. The learned strategy is a linear function of the features which is likely to assign higher scores to “good” variables. In phase II, the learned ranking function is used for branching. Preliminary results indicate that our method is competitive with SB and state-of-the-art strategies in commercial solvers.

2 - Constraint Programming in Data Mining

Tias Guns, KU Leuven, Celestijnenlaan 200A, Leuven, 3000, Belgium, tias.guns@cs.kuleuven.be

The use of constraints is prevalent in data mining, most often to express background knowledge or feedback from the user. Computationally, constraints have been studied for many years by the constraint programming community. In recent years, such technology is increasingly applied in the field of (symbolic) data mining. Many challenges exist though, at the level of modelling the problem (encodings, high-level languages, new primitives) as well as at the solving level (scalability, redundant constraints, search strategies). We review recurring motivations and highlight some of the challenges with MiningZinc, a high-level pattern mining language with solving mechanism that can hybridize specialised algorithms and CP solvers.

3 - Discrete Optimization with Decision Diagrams

Willem-Jan van Hoeve, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, United States of America, vanhoeve@andrew.cmu.edu, David Bergman, Andre Augusto Cire, John Hooker

We present an exact solution approach for discrete optimization problems where decision diagrams play the role of the traditional LP relaxation. Relaxed decision diagrams provide bounds and guidance for branching, while restricted decision diagrams supply a primal heuristic. The search scheme branches within relaxed decision diagrams instead of individual variables. We show that our approach is competitive with, or superior to, a leading MIP solver for the independent set, maximum cut, and maximum 2-SAT problem.

TB20

20- Smithfield

Fast Proximal–Based Algorithms and Dynamical Systems for Structured Optimization: Applications to Signal/Imaging Processing

Cluster: Nonsmooth Optimization

Invited Session

Chair: Hedy Attouch, Professor, Place Eugène Bataillon, Montpellier, 34095, France, attouch@math.univ-montp2.fr

1 - Large Scale Optimization using Multiresolution Analysis and Proximity Operators

Bruce Suter, Air Force Research Laboratory, Rome, NY, 13441-4505, United States of America, bruce.suter@us.af.mil, Lixin Shen

Multiresolution analysis has been widely used for representing data as linear combinations of multiscale basis functions and it facilitates in the designing of fast computational algorithms. Proximity operator has been used extensively in nonlinear optimization. We shall present how multiresolution analysis and proximity operators can be synthesized in a highly innovative fashion to solve large scale optimization problems. Numerical experiments for image deblurring will be presented to show the efficiency of this approach for large scale optimization.

2 - Fast Convergence of an Inertial Gradient-like System with Vanishing Viscosity

Juan Peypouquet, PhD, Univesidad Tecnica Federico Santa Maria, Av Espana 1680, Valparaiso, Chile, juan.peypouquet@sansano.usm.cl, Patrick Redont, Hedy Attouch

We study the fast convergence of the trajectories of a second-order gradient-like system with a vanishing viscosity coefficient depending on a parameter. When the underlying potential has minimizers, each trajectory converges weakly to one of them. Strong convergence occurs in various practical situations. Surprisingly, in the strongly convex case, convergence is arbitrarily fast depending on the values of the parameter. When the solution set is empty, the minimizing property still holds, but the rapid convergence of the values may not be satisfied. Time discretization of this system provides new fast converging algorithms, expanding the field of rapid methods for structured convex minimization.

3 - Dynamics for Multicriteria Optimization

Guillaume Garrigos, PhD, Université de Montpellier, Place Eugène Bataillon, Montpellier, 34095, France, guillaume.garrigos@gmail.com

We present some new results about a continuous dynamic in the context of the multicriteria analysis. It is called the MultiObjective Gradient dynamic (MOG), and can be seen as a vectorial analog of the classic steepest descent. It is a cooperative dynamic whose trajectories makes all the involved functions decrease along time. Moreover, under a convex assumption, the trajectories converge to a weak Pareto point. So, our aim is to introduce the basic tools used in multicriteria analysis, and study the properties of (MOG). We will compare it to a recently studied algorithm, which can be seen as a discretization in time of our dynamic. Finally, we will discuss a second order continuous dynamic, by introducing in (MOG) an inertial term.

TB21

21-Birmingham

Constrained and Multi-Objective Expensive Black-Box Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Rommel Regis, Associate Professor, Saint Joseph’s University, Department of Mathematics, 5600 City Avenue, Philadelphia, PA, 19131, United States of America, rregis@sju.edu

1 - GOSAC: Global Optimization with Surrogate Approximation of Constraints

Juliane Mueller, Postdoc, Lawrence Berkeley National Lab, 1 Cyclotron Road, Berkeley, CA, 94720, United States of America, JulianeMueller@lbl.gov

We introduce GOSAC, a global optimization algorithm for problems with computationally expensive black-box constraint functions. GOSAC uses computationally cheap surrogate models to approximate the constraints. We iteratively select new sample points by minimizing the cheap objective function subject to the surrogate constraint approximations. GOSAC is able to deal with continuous, pure integer, and mixed-integer variables. Numerical experiments show that GOSAC is able to find near optimal solutions for a wide variety of problems.

2 - Parallel Single Objective Surrogate Global Optimization with Multi-Objective and Tabu Search

Christine Shoemaker, Professor, Cornell University, Civil and Environmental Engr., Operations Res. and Info. Engr., Ithaca, NY, 14853, United States of America, cas12@cornell.edu, Tipaluck Krityakierne, Taimoor Akhtar

A parallel surrogate-based continuous global optimization method for computationally expensive, black box objective functions is introduced. Algorithm blends multi-objective non-dominated sorting and tabu search into single objective surrogate optimization. SOP outperformed alternatives on most multimodal test functions. Sufficient conditions for convergence are presented. Sometimes SOP with 8 processors finds an accurate answer in less wall-clock time than the other algorithms get with 32 processors. In four cases, SOP with 32 processors got speedups greater than 32.

3 - Derivative-Free and Surrogate-Based Approaches for Expensive Multi-Objective Black-Box Optimization

Rommel Regis, Associate Professor, Saint Joseph's University, Department of Mathematics, 5600 City Avenue, Philadelphia, PA, 19131, United States of America, rregis@sju.edu

This talk reviews some of the current derivative-free and surrogate-based approaches for the multi-objective optimization of expensive black-box objective functions possibly subject to expensive black-box constraints. It will include provably convergent approaches, including trust-region methods and direct search methods, as well as heuristics such as NSGA-II and methods that use surrogate models for the objective and constraint functions. It will also present numerical results using some of these approaches on test problems with bound constraints only and also on test problems with black-box inequality constraints.

■ TB22

22- Heinz

Recent Advances in Deterministic Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Christodoulos FloudasDirector, Texas A&M Energy Institute, Erle Nye '59 Chair, Professor for Engineering Excellence, Department of Chemical Engineering, College Station, TX, 77843, United States of America, floudas@tamu.edu,floudas@princeton.edu

1 - Convergence Rate of Multivariate McCormick Relaxations

Alexander Mitsos, Professor, RWTH Aaachen University, Turmstr. 46, Aachen, 52064, Germany, alexander.mitsos@avt.rwth-aachen.de, Angelos Tsoukalas, Agustin Bompadre, Jaromil Najman

We consider a recently proposed extension of the McCormick's composition theorem to multi-variate outer functions. In addition to extending the framework, the multi-variate McCormick relaxation is a useful tool for the proof of relaxations: by direct application to the product, division and minimum/maximum of two functions, we obtain improved relaxations when comparing with uni-variate McCormick. We then extend a recently proposed framework for the analysis of convergence rate of convex relaxations to the Multivariate McCormick relaxations. Finally we compare the convergence rate of the new relaxations to established relaxations.

2 - Logic-based Outer-approximation for Global Optimization of GDP

Francisco Trespalacios, PhD Student, Carnegie Mellon University, Department of Chemical Engineering, Doherty Hall, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, ftrespal@andrew.cmu.edu, Ignacio Grossmann

An alternative way to represent MINLP problems is Generalized Disjunctive Programming (GDP) that involves algebraic equations, disjunctions and logic propositions. In this work we present a logic-based outer-approximation algorithm to find the global solution of GDPs involving nonconvex functions in the continuous variables. The algorithm iteratively solves a master MILP and a reduced nonconvex NLP subproblem. The basic algorithm is improved with two main features: a novel derivation of new cuts and a two-stage partition. Numerical results are reported.

3 - Solving MINLP with Heat Exchangers: Special Structure Detection and Large-Scale Global Optimisation

Ruth Misener, Lecturer and RA Engr. Research Fellow, Imperial College London, South Kensington Campus, London, SW7 2AZ, United Kingdom, r.misener@imperial.ac.uk, Miten Mistry

Optimising heat exchangers networks (HEN) may increase efficiency in industrial plants; we develop deterministic global optimisation algorithms for a MINLP model that simultaneously incorporates utility cost, equipment area, and hot / cold stream matches. In this work, we automatically recognise and exploit special mathematical structures common in HEN including log mean temperature difference and Chen approximation; we computationally demonstrate the impact on the global optimisation solver ANTIGONE and benchmark large-scale test cases against heuristic approaches.

■ TB23

23- Allegheny

Robust Optimization Applications

Cluster: Robust Optimization

Invited Session

Chair: Melvyn Sim, Professor, Singapore, melvynsim@gmail.com

1 - Data-Driven Learning in Dynamic Pricing using Adaptive Optimization

Phebe Vayanos, MIT Sloan School of Management, MIT ORC, Office E40-111, 77 Massachusetts Ave, Cambridge, MA, 02139, United States of America, pvayanos@mit.edu, Dimitris Bertsimas

We consider the pricing problem faced by a retailer endowed with a finite inventory of a product offered to price-sensitive customers. The parameters of the demand curve are unknown to the seller who has at his disposal a history of sales data. We show that the seller's problem can be formulated as an adaptive optimization problem with policy-dependent uncertainty set. We obtain a conservative approximation in the form of mixed-binary conic optimization problem that is practically tractable. We present computational results that show that the proposed policies: yield higher profits compared to commonly used policies, and can be obtained in modest computational time for large-scale problems.

2 - Risk-averse Scheduling with Random Service Durations and No-shows under Ambiguous Distributions

Siqian Shen, Assistant Professor, Department of Industrial and Operations Engineering, University of Michigan, 2793 IOE Building, 1205 Beal Avenue, Ann Arbor, MI, 48103, United States of America, siqian@umich.edu, Ruiwei Jiang

We investigate distributionally robust scheduling problems that assign arrival time under random service durations and no-shows, of which the joint distribution is bounded by a confidence set using marginal means. We discuss models that minimize/constrain the worst-case expected cost or CVaR of waiting, idleness, and overtime. We classify three cases of the support of no-shows, each following a prior belief of maximum number of consecutive no-shows. For each case, we either propose a cutting-plane algorithm or derive the convex hull as polynomial-size LPs. We compute diverse instances to demonstrate the efficacy of our approaches and insights of risk hedging in scheduling under heterogeneous uncertainties.

3 - Robust Design of Waste-to-Energy Systems

Adam Ng, Associate Professor, National University of Singapore, 1 Engineering Drive 2, Singapore, Singapore, isentsa@nus.edu.sg, Shuming Wang

Sustainable waste management is an important environmental-energy-economic issue, and various waste treatment technologies capable of recovering useful energy efficiently from different waste stream components are now commercially available. Sound decision-making under uncertainty of future waste generation characteristics is critical, since installing new treatment technologies often involve very high investment costs. We introduce how robust optimization modelling can be used to provide effective support for the analysis and design of sustainable waste-to-energy solutions.

■ TB24

24- Benedum

Mixed-Integer Quadratic Programming

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Jeff Linderoth, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53711, United States of America, linderoth@wisc.edu

1 - Compact Mixed-Integer Formulations of Nonconvex Quadratically Constrained Quadratic Programs

James Foster, Postdoctoral Research Associate, University of Wisconsin-Madison, 330 North Orchard Street, Madison, WI, 53715, United States of America, jfoster@discovery.wisc.edu, James Luedtke

We show how to reformulate a nonconvex quadratically constrained quadratic program (QCQP) into a mixed-integer program composed of linear constraints and second-order cone equations. We then describe the construction of mixed-integer linear programs that approximate the original QCQP to high precision while only introducing a small number of additional variables and constraints. Application to the solution of optimal power flow problems will be presented.

2 - Towards the Exact Solution of Biobjective Mixed Integer Quadratic Programs

Nathan Adelgren, Clemson University, Department of Mathematical Sciences, Clemson, SC, 29634, United States of America, nadelgr@clemson.edu, Margaret Wiecek, Akshay Gupte

In this work we present an algorithm for solving a multiparametric convex QP with parameters in general locations by reformulation of the problem as a multiparametric linear complementarity problem. We use this method to obtain the Pareto set of a multiobjective QP. This method and new branching, fathoming, cutting plane and node relaxation techniques are incorporated into a branch and bound framework designed for computing the complete Pareto set of a biobjective mixed-integer QP.

3 - A Feasible Active Set Method with Reoptimization for Convex Quadratic Mixed-Integer Programming

Long Trieu, TU Dortmund, Vogelpothsweg 87, 44227, Dortmund, Germany, long.trieu@math.tu-dortmund.de, Stefano Lucidi, Christoph Buchheim, Marianna De Santis, Francesco Rinaldi

We present a fast branch-and-bound scheme for solving strictly convex quadratic mixed-integer programs with linear constraints. In each node we solve the continuous relaxation of the dual quadratic program with an effective feasible active set algorithm to get a lower bound. Experimental results for randomly generated instances of several types are presented. Compared with the MIQP solver of CPLEX 12.6, it turns out to be competitive for instances with a small number of constraints.

■ TB25

25- Board Room

Applications in Energy

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Jan Thiedau, Leibniz Universitaet Hannover, Welfengarten 1, Hannover, 30167, Germany, thiedau@ifam.uni-hannover.de

1 - Adaptive Discretization of Nonlinear Optimization Models for Energy Supply Systems

Sebastian Goderbauer, RWTH Aachen University, Lehrstuhl II für Mathematik, Pontdriesch 14/16, Aachen, 52062, Germany, goderbauer@math2.rwth-aachen.de, Björn Bahl, André Bardow, Arie M.C.A. Koster, Marco Lübbecke

Energy supply systems are highly integrated and complex systems to be designed to meet time-varying energy demands in, e.g., heating, cooling, and electricity. Various types of energy conversion units with different capacites, nonlinear investment costs, and nonlinear part-load performances can be chosen. This leads to mixed-integer nonlinear programming (MINLP) problems. We present an adaptive discretization algorithm for such problems containing an iterative interaction between mixed-integer linear programms (MIPs) and nonlinear programms (NLPs), which outperformes state-of-the-art MINLP solvers with regard to solution quality and computation times.

2 - Nonlinear Optimization for Storage of Electric Energy in Gas Networks

Jan Thiedau, Leibniz Universitaet Hannover, Welfengarten 1, Hannover, 30167, Germany, thiedau@ifam.uni-hannover.de, Marc C. Steinbach

The need for storage for highly volatile generated renewable energy can be addressed by electric compressor stations storing energy in terms of pressure increase. We present a transient optimization model that incorporates gas dynamics and technical network elements. Direct discretization leads to an NLP that is solved by interior point methods. We present an analysis on the structure of the arising linear systems as well as results for simple pipelines.

■ TB26

26- Forbes Room

Optimization with Stochastic Preference Constraints

Cluster: Stochastic Optimization

Invited Session

Chair: Nilay Noyan, Associate Professor, Sabanci University, Istanbul, Turkey, nnoyan@sabanciuniv.edu

1 - Robust Multicriteria Risk-Averse Stochastic Programming

Simge Kucukyavuz, Ohio State University, 1971 Neil Ave, 244 Baker Systems, Columbus, OH, 43210, United States of America, kucukyavuz.2@osu.edu, Nilay Noyan, Xiao Liu

We study risk-averse models for multicriteria optimization problems under uncertainty. We use a weighted sum-based scalarization and consider a set of scalarization vectors to address the ambiguity and inconsistency in the relative weights of each criterion. We introduce a model that optimizes the worst-case multivariate CVaR and develop a finitely convergent cut generation algorithm for finite probability spaces. We show that this model can be reformulated as a compact LP for certain scalarization sets. We give a stronger formulation for the cut generation MIP for the equiprobable case, which is also useful for a related class of CVaR-constrained problems. Our computational study illustrates the effectiveness of the proposed methods.

2 - Two-Stage Optimization Problems with Multivariate Stochastic Dominance Constraints

Eli Wolfhagen, Stevens Institute of Technology, 1 Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, ewolfhagen@gmail.com

This talk will present methods for solving two-stage stochastic optimization problems with multivariate stochastic dominance constraints. A two-stage portfolio optimization application will be discussed and the numerical performance of the methods will be analyzed.

■ TB27

27- Duquesne Room

Optimization Models for Renewable Energy

Cluster: Optimization in Energy Systems

Invited Session

Chair: Suvrajeet Sen, Professor, University of Southern California, Industrial and Systems Eng, Los Angeles, CA, 90403, United States of America, s.sen@usc.edu

1 - Regularized Decomposition Method for Multistage Stochastic Programs

Tsvetan Asamov, Postdoctoral Research Assocua, Princeton University, ORFE, Princeton, NJ, United States of America, tasamov@princeton.edu, Warren Powell

Stochastic Dual Dynamic Programming is one of the best known algorithms for the solution of convex multistage stochastic optimization problems. Despite its growing popularity, SDDP can exhibit slow convergence and lead practitioners to a difficult choice between solution quality and computational time. In this work, we develop the first quadratic regularization method for the SDDP framework. Unlike existing regularization techniques on scenario trees, our approach remains computationally tractable even for problems with long time horizons. Our numerical results indicate that the proposed solution exhibits significantly faster convergence than classical SDDP and is especially useful for problems with high-dimensional value functions.

2 - Assessment of Reservoir Aggregation in the Long-Term Hydrothermal Scheduling

Vitor de Matos, Plan 4 Engenharia, Rua Lauro Linhares, 2055, sala 707-Max, Florianopolis, SC, 88036003, Brazil, vitor@plan4.com.br, Erlon Finardi, Paulo Larroyd

The Long-Term Hydrothermal Scheduling plays an important role in power systems that rely heavily on hydroelectricity as its goal is to define a policy for the use of water. The Brazilian system has hundreds of hydro plants and some simplifications are made in their modeling in order to reduce the computational burden. As a result, this paper assesses the consequences of those simplifications in the operation policies. Results are shown considering the Brazilian power system.

3 - Multiple Timescale Stochastic Optimization for Integrating Renewable Resources

Harsha Gangammanavar, Visiting Assistant Professor, University of Southern California, 3715 McClintock Avenue, GER 240, Los Angeles, CA, 90089, United States of America, gangamma@usc.edu, Suvrajeet Sen

We will present a multiple timescale stochastic economic dispatch model to capture a decision process with coarse timescale for thermal generation, and a fine timescale for network, storage and renewable utilization. This model will be tackled using two solution approaches: a joint stochastic decomposition-approximate dynamic programming (SD-ADP) algorithm for centralized storage systems (scalar states), and a time-staged stochastic decomposition(TSD) algorithm for systems with distributed storage (vector valued states). The TSD algorithm can be interpreted as a recursive contraction mapping similar to the DP operator. We will present convergence properties and computational results for both these algorithmic frameworks.

■ TB28

28- Liberty Room

Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Tibor Csendesprof., University of Szeged, Arpad ter 2, Szeged, 6720, Hungary, csendes@inf.u-szeged.hu

1 - Globally Solving Non-Convex Quadratic Programming Problems via Linear Integer Programming Techniques

Wei Xia, Lehigh University, 312 Brodhead Ave, Apt. C, Bethlehem, PA, 18015, United States of America, wex213@lehigh.edu, Juan Vera, Luis Zuluaga

A quadratic programming (QP) problem is a well-studied and fundamental NP-hard optimization problem in which the objective is quadratic and the constraints are linear on the decision variables. In this paper, we propose an alternative way of globally solving non-convex quadratic optimization problems by taking advantage of the Karush-Kuhn-Tucker (KKT) problem's conditions to linearize its objective. Then, the problem is reformulated as a mixed integer linear problem (MILP) by using binary variables to model the KKT complementary constraints. To illustrate this, we compare the performance of this solution approach with the current benchmark global QP solver QuadprogBB on a large variety of test QP instances.

2 - Optimization in Surgical Operation Design

Tibor Csendes, Prof., University of Szeged, Arpad ter 2, Szeged, 6720, Hungary, csendes@inf.u-szeged.hu, Istvan Szalay, Istvan Barsony

A treatment of oncological diseases is brachytherapy that is the insertion of low level radiation isotopes into the organ to be healed. The problem is to determine how to position the 40-90 capsules in such a way that the tissue to be healed should obtain at least a given level of dose, while the surrounding other organs should absorb a dose less than a prescribed level. The related nonlinear optimization problem is of medium dimensionality (120-270). The global optimization problem is very redundant, and symmetric. The present work aims to speed up the optimization, to allow different intensity radiation capsules, and to decrease the cost of the treatment. The first test results obtained for artificial models are reported.

3 - Disjunctive Programming and Global Optimization

Peter Kirst, Karlsruhe Institute of Technology (KIT), Institute of Operations Research, Kaiserstrasse 12, Karlsruhe, 76131, Germany, peter.kirst@kit.edu, Oliver Stein, Fabian Rigterink

We propose a new branch-and-bound algorithm for global optimization of disjunctive programs with general logical expressions. In contrast to the widely used reformulation as a mixed-integer program we propose to directly process the logical expression in the construction of the lower bounds. Thus we do not only reduce the size of the problem but also have purely continous variables which is advantageous for computations.

■ TB29

29- Commonwealth 1

Algorithms for Nonsmooth-Nonconvex Optimization: Theory and Practice

Cluster: Nonsmooth Optimization

Invited Session

Chair: Russell Luke, University of Goettingen, Institute for Numerical and Applied Math, Goettingen, 39083, Germany, r.luke@math.uni-goettingen.de

1 - A Dual Method for Minimizing a Nonsmooth Objective over One Smooth Inequality Constraint

Marc Teboulle, Professor, School of Mathematical Sciences, Tel Aviv University, Ramat Aviv, Tel Aviv, IL, 69978, Israel, teboulle@post.tau.ac.il, Ron Shefi

We consider the class of nondifferentiable convex problems which minimizes a nonsmooth convex objective over a smooth inequality constraint. Exploiting the smoothness of the feasible set and using duality, we introduce a simple first order algorithm proven to globally converge to an optimal solution with a sublinear rate. The performance of the algorithm is demonstrated by solving large instances of the convex sparse recovery problem.

2 - An Alternating Semi-Proximal Method for Nonconvex Problems

Shoham Sabach, Assistant Professor, Technion - Israel Institute of Technology, Faculty of Industrial Engineering, Technion City, Haifa, IL, 32000, Israel, ssabach@ie.technion.ac.il, Marc Teboulle, Amir Beck

We consider a broad class of regularized structured total-least squares problems (RSTLS) encompassing many scenarios in image processing. This class of problems results in a nonconvex and often nonsmooth model in large dimension. To tackle this difficult class of problems we introduce a novel algorithm which blends proximal and alternating minimization methods by beneficially exploiting data information and structures inherently present in RSTLS. The proposed algorithm which can also be applied to more general problems is proven to globally converge to critical points, and is amenable to efficient and simple computational steps.

3 - Finite Identification and Local Linear Convergence of Proximal Splitting Algorithms

Jalal Fadili, Professor, CNRS-ENSICAEN-Univ. Caen, 6 Bd Marechal Juin, Caen, 14050, France, Jalal.Fadili@ensicaen.fr, Gabriel Peyré, Jingwei Liang

Convex nonsmooth optimization has become ubiquitous in most quantitative disciplines of science. Proximal splitting algorithms are very popular to solve structured convex optimization problems. Within these algorithms, the Forward-Backward and its variants (e.g. inertial FB, FISTA, Tseng's FBF), Douglas-Rachford and ADMM are widely used. The goal of this work is to establish the local convergence behavior of these schemes when the involved functions are partly smooth relative to their active manifolds. We show that all these splitting methods correctly identify the active manifolds in a finite time, and then enter a local linear convergence regime, which we characterize precisely. This is illustrated by several numerical experiments.

■ TB30

30- Commonwealth 2

Approximation and Online Algorithms V

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Mohit Singh, Microsoft Research, One Microsoft Way, Redmond, United States of America, mohits@microsoft.com

1 - Approximation Algorithms for (Citi)Bike Sharing Operations

Eoin O'Mahony, Cornell University, Upson Hall, Ithaca, NY, 14853, United States of America, eoindom@gmail.com, David Shmoys

Bike-sharing systems are becoming increasingly prevalent in urban environments. The management of these systems requires dealing with the issue of bicycle rebalancing. Users imbalance the system by creating demand in an asymmetric pattern; this necessitates intervention to restore balance and facilitate future use. This talk presents a 3-approximation algorithm used to target limited available rebalancing resources during rush-hour periods. The goal is to ensure that users are never too far from a station that will be rebalanced when looking for a bike or a spot to return one. We formulate this as a variant of the k-center problem and provide a linear programming-based algorithm with a performance guarantee of 3.

2 - How to Round Subspaces: A New Spectral Clustering Algorithm

Ali Kemal Sinop, Postdoc, Simons Institute for the Theory of Computing, 121 Calvin Lab, UC Berkeley, Berkeley, CA, 94720, United States of America, asinop@cs.cmu.edu

Consider the problem of approximating a k-dimensional linear subspace with another k-piecewise constant subspace in spectral norm. Our main contribution is a new spectral clustering algorithm: It can recover a k-partition such that the subspace corresponding to the span of its indicator vectors is square root of OPT close to the original subspace in spectral norm, with OPT being the minimum possible. Previously, no algorithm was known which could find a k-partition closer than o(k OPT). We present two applications for our algorithm. First one approximates a given graph in terms of disjoint union of k-expanders. The second one approximates a k-partition provided its clusters have expansion less than (k+1)th smallest eigenvalue of Laplacian.

3 - LP-Based Algorithms for Capacitated Facility Location

Mohit Singh, Microsoft Research, One Microsoft Way, Redmond, WA, United States of America, mohits@microsoft.com, Ola Svensson, Hyung-Chan An

Many of our best (approximation) algorithms for hard combinatorial optimization problems rely on linear programming relaxations. A typical example is the uncapacitated facility location problem for which a sequence of LP-based algorithms have resulted in close to optimal algorithms. For the more general capacitated facility location problem, the situation is drastically different as all proposed relaxations fail to give any reasonable guarantees on the value of an optimal solution. In fact, the only known algorithms with good performance guarantees are based on the local search paradigm. We overcome this difficulty by giving the first relaxation of the capacitated facility location with a constant integrality gap.

Tuesday, 1:10pm - 2:40pm

■ TC01

01- Grand 1

Open-Source Tools for Optimization

Cluster: Implementations and Software

Invited Session

Chair: Matthew Saltzman, Clemson University, Mathematical Sciences Department, Martin Hall, Box 340975, Clemson, SC, 29634, United States of America, mjs@clemson.edu

1 - Distributed Parallel Greedy Block Coordinate Descent for Graphical Lasso

Alireza Yektamaram, Lehigh University, Department of Industrial Engineering, Bethlehem, PA, 18015, United States of America, sey212@lehigh.edu, Katya Scheinberg

Among various problems in Machine learning, Graphical Lasso aims to recover Sparse Inverse Covariance Matrix of a Markov random field which corresponds to discovering structure of the underlying dependency graph of random variables. In this setting as the problem size grows larger, efficiency of most solution approaches reduces significantly, hence use of distributed parallel techniques become essential. In this study, we propose a coordinate descent approach with new update formulas that converges faster using parallel libraries.

2 - Pyomo 5.0

William Hart, Manager, Sandia National Laboratory, P.O. Box 5800, Albuquerque, MI, 87185, United States of America, wehart@sandia.gov

This presentations describes recent advances in the Pyomo optimization modeling software. Pyomo is a Python-based optimization and modeling framework that includes sophisticated meta-solvers and model transformations. The Pyomo 5.0 release includes maturation of bilevel program and MPEC modeling components, a generic Benders solver, and support for JIT Python implementations (PyPy, Jython and IronPython).

3 - RLT-POS: Reformulation-Linearization Technique-based Optimization Software for POPs

Evrim Dalkiran, Assistant Professor, Wayne State University, 4815 4th St. MEB # 2149, Detroit, MI, 48202, United States of America, evrimd@wayne.edu, Hanif Sherali

We introduce a Reformulation-Linearization Technique-based open-source optimization software for solving polynomial programming problems (RLT-POS). We present algorithms that form the backbone of RLT-POS, including constraint filtering techniques, reduced RLT representations, and semidefinite cuts. The coordination between different model enhancement techniques becomes critical for an improved overall performance. We discuss the coordination between 1)constraint elimination via filtering techniques and reduced RLT representations, and 2)SDP cuts for sparse problems. We present computational results to demonstrate the improvement over a standard RLT implementation and to compare the performances of BARON, COUENNE, and SparsePOP with RLT-POS.

■ TC02

02- Grand 2

Maintenance, Restoration, and Reliability in Electric Energy Systems

Cluster: Optimization in Energy Systems

Invited Session

Chair: Andy Sun, Assistant Professor, Georgia Institute of Technology, 765 Ferst Drive, Room 444 Groseclose Bld., Atlanta, GA, 30332, United States of America, andy.sun@isye.gatech.edu

1 - Power System Restoration with Integrated Sectionalization and Generator Start-up Sequencing

Feng Qiu, Researcher, Argonne National Lab, Chicago, IL, United States of America, fqiu@anl.gov, Jianhui Wang, Chen Chen

During power system restoration, the system is normally first sectionalized into a set of subsystems in which the generators are started afterwards. We propose an integer programming formulation to model the sectionalization problem as a graph partition problem with connectivity constraints. We propose a continuous-time representation of the generator start-up sequencing problem. Then, we integrate the two formulations into a single model that minimizes the restoration duration for the overall system. Our case study shows that the proposed model can achieve a global optimization solution effectively.

2 - A New Optimization Framework for Sensor-Driven Generation Maintenance Scheduling

Murat Yildirim, Research Assistant, Georgia Institute of Technology, Atlanta, GA, United States of America, murat@gatech.edu, Andy Sun, Nagi Gebraeel

We provide a unified framework that links low-level performance and condition monitoring data with high-level operational and maintenance decisions for generators. The operational decisions identify the optimal commitment and dispatch to satisfy demand and transmission constraints. Maintenance decisions focus on arriving at an optimal condition based maintenance (CBM) schedule that accounts for optimal asset-specific CBM schedules driven by the condition monitoring data. We propose new mixed-integer optimization models and efficient algorithms that exploit the special structure of the proposed formulation. We present extensive computational experiment results to show proposed models achieve significant improvements in cost and reliability.

3 - Minimal Reschedules in Security-Constrained Optimal Power Flow via Sparsity Regularization

Dzung Phan, Research Staff Member, IBM Watson Research Center, 1101 Kitchawan Rd, Yorktown Heights, NY, 10598, United States of America, phandu@us.ibm.com, Andy Sun

We present a new mathematical formulation for the corrective security-constrained optimal power flow problem. The goal is to produce a generation schedule which has a minimal number of post-contingency corrections as well as a minimal amount of total MW rescheduled. We also propose an efficient decomposition algorithm to solve the problem.

■ TC03

03- Grand 3

Resource Sharing and Routing in Chip Design

Cluster: Combinatorial Optimization

Invited Session

Chair: Stephan Held, Bonn University, Lennestr. 2, Bonn, Germany, held@or.uni-bonn.de

1 - Global Routing with Timing Constraints

Daniel Rotter, University of Bonn, Lennestr. 2, Bonn, 53113, Germany, rotter@or.uni-bonn.de, Stephan Held, Dirk Müller, Vera Traub, Jens Vygen

One of the most successful approaches for the classical global routing problem is the min-max resource sharing algorithm, generalizing the multi-commodity flows. We show how to extend this algorithm to incorporate global static timing constraints and respect them similarly to congestion constraints. The resource sharing algorithm trades off wiring congestion and timing, and balances slacks along the timing graph such that the maximum overall violation is minimized. Our algorithm works for most common delay models and yields the first compact resource sharing formulation of a global routing problem with timing constraints. We demonstrate the benefit of a timing-driven global router by experimental results on industrial VLSI instances.

2 - Detailed Routing Algorithms for Advanced Technology Nodes

Dirk Müller, Research Institute for Discrete Mathematics, University of Bonn, Lennestr. 2, Bonn, 53113, Germany, mueller@or.uni-bonn.de, Gustavo Tellez, Sven Peyer, Markus Ahrens, Michael Gester, Niko Klewinghaus, Christian Schulte

We present algorithms for efficient and almost design rule clean VLSI routing in advanced technology nodes, in presence of dense standard cell libraries and complex industrial design rules, with a special focus on multiple patterning lithography. Our key contributions are a multi-label interval-based shortest path algorithm for long connections, and a dynamic program for computing packings of pin access paths and short connections between closely spaced pins. We combine our algorithms with an industrial router for cleaning up the remaining design rule violations, and demonstrate superior results over that industrial router in our experiments in terms of wire length, number of vias, design rule violations and runtime.

3 - Algorithms for the Gate Sizing Problem in Chip Design

Ulrike Schorr, Research Institute for Discrete Mathematics Bonn, Lennestr. 2, Bonn, Germany, schorr@or.uni-bonn.de, Stephan Held, Nicolai Haehnle

In chip design, a discrete set of physical layouts (sizes) is available for each gate/transistor on the chip, which differ in their power consumption and influence the speed of electrical signals. The gate sizing problem consists of choosing gate sizes minimizing power consumption subject to speed constraints. A popular approach is based on Lagrange relaxation of a geometric program and the subgradient method, converging (slowly) to the optimum in the continuous relaxation. In practice, variants are used that update the Lagrange multiplier multiplicatively without any convergence guarantees. We show that a multiplicative update rule following the resource sharing paradigm gives a fast approximation of the continuous relaxation.

■ TC04

04- Grand 4

Structured Semidefinite Programs and Their Applications

Cluster: Conic Programming

Invited Session

Chair: Etienne de Klerk, Tilburg University, 1 Warandelaan, Tilburg, Netherlands, e.deklerk@uvt.nl

1 - Keller's Cube Tiling Conjecture: An Approach through SDP Hierarchies

Dion Gijswijt, Delft University of Technology, Mekelweg 4, Delft, Netherlands, D.C.Gijswijt@tudelft.nl

Keller's conjecture states that any tiling of Euclidean space by unit cubes must contain a pair of cubes sharing a full face. For any dimension, the problem can be formulated as a stable set problem in a very large and highly symmetric graph. In this talk we show how the symmetry can be used to approach Keller's conjecture through semidefinite programming hierarchies.

2 - New Upper Bounds for the Density of Translative Packings of Superspheres

Frank Vallentin, University of Köln, Köln, Germany, frank.vallentin@uni-koeln.de

In this talk I provide new upper bounds for the maximal density of translative packings of superspheres in three dimensions (unit balls for the l^p_3-norm). I present some strong indications that the lattice packings found in 2009 by Jiao, Stillinger, and Torquato are indeed optimal among all translative packings. For this I apply the linear programming bound of Cohn and Elkies which originally was designed for the classical problem of packings of spheres. The proof of the new upper bounds is computational and rigorous. The main technical contribution is the use of invariant theory of reflection groups in polynomial optimization. (joint work with Maria Dostert, Cristobal Guzman, and Fernando Oliveira)

3 - On the Turing Model Complexity of Interior Point Methods for SDP

Etienne de Klerk, Tilburg University, 1 Warandelaan, Tilburg, Netherlands, e.deklerk@uvt.nl, Frank Vallentin

Semidefinite programming (SDP) is used in many polynomial-time approximation algorithms, like the Goemans-Williamson algorithm for the maximum cut problem. To give a rigorous proof of the polynomial running time, the ellipsoid method of Yudin and Nemirovski is usually invoked, since the Turing model complexity of the more practical interior point methods (IPMs) is not well-understood. In this talk we show how one may obtain rigorous complexity results for IPMs in the SDP case.

■ TC05

05- Kings Garden 1

Algorithms for Large-Scale Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Joshua Griffin, SAS Institute Inc., 100 SAS Campus Drive, Cary, NC, United States of America, Joshua.Griffin@sas.com

1 - Compact Representations of Quasi-Newton Matrices

Roummel Marcia, Associate Professor, University of California, Merced, 5200 N. Lake Road, Merced, Ca, 95343, United States of America, rmarcia@ucmerced.edu, Jennifer Erway

Very large systems of linear equations arising from quasi-Newton methods can be solved efficiently using the compact representation of the quasi-Newton matrices. In this paper, we present a compact formulation for the entire Broyden convex class of updates for limited-memory quasi-Newton methods and how they can be used to solve large-scale trust-region subproblems with quasi-Newton Hessian approximations.

2 - Extension of the Multi-Start Algorithm to Mixed Integer Nonlinear Programming

Tao Huang, SAS Institute Inc., 100 SAS Campus Drive, Cary, NC, 27513, United States of America, Tao.Huang@sas.com

We present an implementation of the multi-start algorithm for continuous nonlinear optimization as is extended to handle integer variables. Schemes to generate sample points under integer requirements are discussed. In the cases where no feasible integer sample point is generated, an algorithm is proposed to seek feasible integer points. The properties of the integer-seeking algorithm is discussed. Our multi-start algorithm exploits parallelism in different phases of the algorithm and as a result the solution times are drastically reduced. Preliminary numerical results are presented to show its efficacy.

3 - Optimization on Riemannian Manifolds: Methods and Applications to Matrix Manifolds

Murugiah Muraleetharan, SAS Institute Inc., 100 SAS Campus Drive, Cary, NC, 27513, United States of America, M.Muraleetharan@sas.com

We discuss Riemannian optimization methods for optimizing functions over manifolds. Algorithms, such as steepest descent, nonlinear conjugate-gradients, and Newton-based trust-region methods can be re-derived in the Riemannian setting and consequently applied to constrained optimization problems whose constraints can be interpreted as Grassmann and Stiefel manifolds. These manifolds represent the constraints that arise in such areas as singular value decomposition, matrix completions, and extreme eigen-pairs of a symmetric matrix. Riemannian optimization methods lead to practical globally convergent algorithms that scale to large-scale matrix problems while providing a gateway to modify solution requirements on classical decompositions.

■ TC06

06- Kings Garden 2

Novel Applications of Mathematical Programming to Communication and Social Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Arie M.C.A. Koster, Professor, RWTH Aachen University, Lehrstuhl II für Mathematik, Aachen, 52056, Germany, koster@math2.rwth-aachen.de

1 - The Positive Influence Dominating Set Polytope

S. Raghavan, University Of Maryland-College Park, The Smith School Of Business, College Park, MD, 20742, United States of America, raghavan@umd.edu, Rui Zhang

We study the Positive Influence Dominating Set (PIDS) problem that is motivated by applications connected to social networks. In particular, we study the PIDS problem and polytope on trees. First, we show that the PIDS problem on trees can be solved in linear time via a dynamic programming algorithm. Next, we provide a tight and compact extended formulation, and derive the PIDS polytope for trees. We then obtain a strong formulation for the PIDS problem on general graphs. Computational experience will be discussed.

2 - Column Generation Models for Chromatic Scheduling

Olaf Maurer, olaf.maurer@mathematik.uni-kassel.de, Heinrich-Plett-Strafle 40B, Kassel, 34132, Germany, olaf.maurer@mathematik.uni-kassel.de, Andreas Bley, Benjamin Müller, Mohsen Rezapour

We address the chromatic scheduling problem, which arises in the planning of flexgrid fiber optic communication networks. Given a set of fixed paths with integer demands, the task is to assign to each path an interval of length equal to the path's demand such that intervals that correspond to paths sharing an edge are disjoint. We present an exact two-stage algorithm based on branch-and-price. We employ ILP-based heuristics in the first stage. If this stage fails to prove optimality, we run a branch-and-price algorithm based on an exact ILP formulation for interval coloring. We present the results of our computational experiments in which this approach turns about to be efficient, solving instances of realistic size in seconds.

3 - Virtual Network Embedding: Computational Complexity and Valid Inequalities

Martin Tieves, RWTH Aachen University, Lehrstuhl II für Mathematik, Pontdriesch 14/16, Aachen, 52062, Germany, tieves@math2.rwth-aachen.de, Arie M.C.A. Koster, Stefano Coniglio

Network virtualization techniques are introduced to separate offered services from the operation of the physical network they base on. In this talk, we focus on the virtual network embedding problem (VNE), i.e., the optimal admission of virtual networks to a physical network. We investigate it's computational complexity for several special cases. Further, we show how an MILP formulation can be improved by deriving valid inequalities.

■ TC07

07- Kings Garden 3

Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Friedrich Eisenbrand, EPFL, Station 8, Lausanne, 1015, Switzerland, friedrich.eisenbrand@epfl.ch

1 - On Approximating the Knapsack Polytope

Yuri Faenza, EPFL, EPFL SB MATH AA MA C1 573, Lausanne, 1015, Switzerland, yuri.faenza@gmail.com, Laura Sanita

The knapsack polytope P is the convex hull of the characteristic vectors of feasible solutions to the 0-1 knapsack problem. Recent results showed that P cannot be described using only a polynomial number of inequalities. But what if we want to describe a polytope P' containing P and approximating it in such a way that, for each objective function c, the maximum of c over P' is at most (1+ epsilon) times the maximum of c over P, for some arbitrarily nonnegative epsilon? In this talk, we present some results on this question, focusing on the case when we require P' to be described via inequalities in the original space. Joint work with Laura Sanita.

2 - Polyhedrality of Maximal S-free Sets

Marco Di Summa, Universite degli Studi di Padova, Dipartimento di Matematica, Via Trieste 63, Padova, PD, 35121, Italy, disumma@math.unipd.it, Michele Conforti

The theory of cut generating functions is a powerful tool for the polyhedral study of integer and mixed integer programming problems, as well as many generalizations of those problems. For a given feasible region S, a key concept in this context is that of maximal S-free sets, i.e., convex sets that do not contain points of S in their interior and are maximal with this property. Since the theory of cut generating functions proves particularly useful when maximal S-free sets are polyhedra, it is natural to ask when this is the case and when it is possible to bound the number of facets of these sets. We present several new results in this direction. (Joint work with Michele Conforti.)

3 - Center-points: A Link between Discrete Geometry and Optimization

Timm Oertel, ETH Zurich, Raemistrasse 101, Zurich, 8092, Switzerland, timm.oertel@ifor.math.ethz.ch

In this talk, I will consider mixed-integer convex minimization problems. First, I will present optimality conditions for this class of optimization problems. Then, I will introduce the concept of center-points, a generalization of the median from the one dimensional space to vector spaces. Through the theory of center-points I will show how to extend the general cutting plane scheme from the continuous setting to the mixed-integer setting. Further, I will present several properties of center-points and how to compute them approximately.

■ TC08

08- Kings Garden 4

TSP and Graph Connectivity

Cluster: Combinatorial Optimization

Invited Session

Chair: Alantha Newman, CNRS, G-SCOP, 46 Avenue Fèlix Viallet, Grenoble, 38000, France, alantha.newman@grenoble-inp.fr

Co-Chair: Sylvia Boyd, University of Ottawa, sylvia@site.uottawa.ca

1 - Improved Approximation Guarantees for Graph-TSP on Subquartic Graphs

Alantha Newman, CNRS, G-SCOP, 46 Avenue Félix Viallet, Grenoble, 38000, France, alantha.newman@grenoble-inp.fr

We discuss approximation algorithms for the graph-TSP problem on subquartic graphs (degree at most four). In particular, we consider the recent framework introduced by Mˆmke and Svensson in which the graph-TSP problem is reduced to computing a minimum-cost circulation in a certain network. Computing an approximation guarantee for graph-TSP is then equivalent to computing an upper bound on the minimum-cost circulation. Mucha's improved analysis of Mˆmke and Svensson's algorithm showed that, hypothetically, the worst-case approximation guarantee of 13/9 could be tight for subquartic graphs. We show that this is not the case, and we present an improved analysis for this class of graphs.

2 - Improved Integrality Gap Upper Bounds for TSP with Distances One and Two

Matthias Mnich, University of Bonn, Department of Computer Science, Friedrich Ebert Allee 144, Bonn, NW, 53113, Germany, mmnich@uni-bonn.de, Tobias Moemke

We study the structure of solutions to the subtour elimination linear programming relaxation for the traveling salesperson problem with one additional cutting plane inequality. For undirected instances we obtain an integrality gap upper bound of 5/4, and of 7/6 if the optimal LP solution is half-integral. For instances of order n with fractional LP value n, we obtain a tight integrality gap upper bound of 10/9 if there is an optimal solution with subcubic support.

3 - Toward a 6/5 Bound for the Minimum Cost 2-Edge Connected Subgraph Problem

Sylvia Boyd, University of Ottawa, sylvia@site.uottawa.ca, Philippe Legault

Given a complete graph G =(V,E) with non-negative edge costs c, the problem 2EC is that of finding a 2-edge connected spanning multi-subgraph of G of minimum cost. The linear programming relaxation 2EC_LP gives a lower bound for 2EC, and it has been conjectured that its integrality gap is 6/5. In this paper, we explore the idea of using the structure of solutions for 2EC_LP and the concept of convex combination to obtain improved approximation algorithms for 2EC. We focus our efforts on a family J of half-integer solutions that appear to give the largest integrality gap for 2EC_LP. We successfully show that for any x* in J, there exists a solution for 2EC of cost at most (6/5)cx*, proving that the conjecture holds true for this family.

■ TC09

09- Kings Garden 5

Semidefinite Hierarchies for Approximations in Combinatorial Optimization II

Cluster: Combinatorial Optimization

Invited Session

Chair: Monique Laurent, CWI & Tilburg University, Science Park 123, Amsterdam, Netherlands, M.Laurent@cwi.nl

Co-Chair: Nikhil Bansal, Dr., Technical University Eindhoven, Eindhoven, Netherlands, bansal@gmail.com

1 - On Unifying the Analyses of Strong Lift-and-Project Methods

Yu Hin Au, Dr., Milwaukee School of Engineering, 1025 N Broadway, Milwaukee, WI 53209, United States of America, au@msoe.edu, Levent Tuncel

Lift-and-project methods is a relatively modern approach for generating tight, tractable relaxations for integer programming problems that has received a lot of research attention in the last 25 years. In this talk, I will give a brief overview about the lift-and-project approach, and present some general tools that can help with analyzing the performances of these algorithms. In particular, we introduce many new variants of Sherali-Adams and Bienstock-Zuckerberg operators, and provide new techniques to analyze the worst-case performances as well as relative strengths of these operators in a unified way. We will also discuss some of their implications on polytopes related to matching and stable set problems.

2 - Approximation Resistance in LP and SDP Hierarchies

Madhur Tulsiani, Dr., Toyota Technological Institute at Chicago, 6045 S Kenwood Avenue, Chicago, IL 60637, United States of America, madhurt@ttic.edu, Subhash Khot, Pratik Worah

For a predicate f:{-1,1}^k \to {0,1} with \rho(f) = |f^{-1}(1)|/2^k, we call the predicate approximation resistant if given a near-satisfiable instance of CSP(f), it is computationally hard to find an assignment satisfying more than (\rho(f)+\eps)-fraction of constraints for every \eps>0. We will discuss a few variants of the notion of approximation resistance and discuss conditions characterizing (these variants of) approximation resistance in LP and SDP hierarchies. Based on joint work with Subhash Khot and Pratik Worah.

3 - Approximating Maximum Independent Set in Sparse Graphs

Nikhil Bansal, Dr., Technical University Eindhoven, Eindhoven, Netherlands, bansal@gmail.com

We consider the maximum independent set problem on graphs with maximum degree d. The best known result for the problem is an SDP based O(d log log d/ log d) approximation. It is also known that no o(d/ log^2 d) approximation exists assuming the Unique Games Conjecture. We will describe several new results for this problem. We show that the natural LP formulation for the problem strengthened by poly-logarithmic levels of the Shearli-Adams(+) hierarcy has an integrality gap of about O(d/log^2d), and discuss some algorithmic aspects.

■ TC10

10- Kings Terrace

Finance and Economics

Cluster: Finance and Economics

Invited Session

Chair: Bulat Gafarov, Pennsylvania State University, 4310 Crescent St., Apt. 2308, Long Island City, NY, 11101, United States of America, bzg134@psu.edu

1 - Computing Near-optimal Value-at-Risk portfolios using Integer Programming Techniques

Onur Babat, PhD Candidate, Lehigh University, 217 West Packer Avenue Apt 106, Bethlehem, PA, 18015, United States of America, onur.babat@lehigh.edu, Juan Vera, Luis Zuluaga

It is difficult to compute optimal VaR portfolios. This is due to VaR being non-convex and of combinatorial nature. It is also well-known that the VaR portfolio problem can be formulated as an integer program (IP) that is difficult to solve with current IP solvers for large-scale instances of the problem. To tackle this drawback, we present an algorithm to compute near-optimal VaR portfolios that takes advantage this IP formulation and provides a guarantee of the near-optimality of the solution. To illustrate the efficiency of the presented algorithm, numerical results are presented.

2 - On the Maximum and Minimum Response to an Impulse SVARs

Bulat Gafarov, Pennsylvania State University, 4310 Crescent St., Apt. 2308, Long Island City, NY, 11101, United States of America, bzg134@psu.edu, Jose Luis Montiel Olea

This paper proposes an intuitive, computationally simple, "adjusted" delta method confidence interval for set-identified coefficients of the impulse-response function in a Structural Vector Autoregression. We establish the uniform asymptotic validity of our inference procedure in models that impose zero and sign restrictions only on the contemporaneous responses to one structural shock. We treat the bounds of the identified set for the coefficients of impulse-responses as the maximum and minimum value of a mathematical program and we provide formulas for these values and their derivative. To illustrate our inference approach, we use a monetary Structural Vector Autoregression estimated with monthly U.S. data.

3 - DEA Indicators of Efficiency for the Companies Insurance Brokers in the Colombian Financial Means

Gloria Rodríguez, Universidad Nacional de Colombia, Ciudad Universitaria Edificio 311, Bogota, Colombia, girodriguezl@unal.edu.co

In the different countries worldwide financial traditional indicators are in use for evaluating the performance organizational of the companies, nevertheless these traditional indicators do not assure to approach a process of capture of decisions based on a minor risk; for everything previous it is necessary to approach other methodologies. The area of the companies' insurance brokers it shapes a good platform for the implementation and analysis of Date Envelopment Analysis DEA.

■ TC11

11- Brigade

Submodularity

Cluster: Combinatorial Optimization

Invited Session

Chair: Feng Li, PhD, Northeastern University, #135 The Logistics Institute, Shenyang, LN, 110819, China, fengli055@gmail.com

1 - A Generalized Polymatroid Approach to Stable Allocations with Lower Quotas

Yu Yokoi, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan, Yu_Yokoi@mist.i.u-tokyo.ac.jp

Classified Stable matching model, introduced by Huang (2010), is NP-hard in general, but solvable if its upper and lower quotas are defined only on a laminar family. Fleiner and Kamiyama (2012) have given a matroid theoretic interpretation to the latter result. In this talk, we generalize their results in terms of generalized polymatroids. We give an algorithm which finds a stable matching (or reports the nonexistence) in polynomial time and show the lattice structure of stable matchings.

2 - Finding a Stable Allocation in Polymatroid Intersection

Satoru Iwata, Professor, University of Tokyo, Deptartment of Mathematical Informatics, Tokyo, 113-8656, Japan, iwata@mist.i.u-tokyo.ac.jp, Yu Yokoi

As a generalization of stable matching of Gale and Shapley (1962), the concepts of matroid kernel and stable allocation were introduced respectively by Fleiner (2001) and by Baiou and Balinski (2002). This talk introduces a common generalization of these two, which we call a stable allocation in polymatroid intersection. We provide an algorithm for finding a stable allocation in strongly polynomial time, provided that oracles for computing exchange capacities are available.

3 - Integrated Scheduling of Production and Energy Consumption with Submodular Cost

Feng Li, PhD, Northeastern University, #135 The Logistics Institute, Shenyang, LN, 110819, China, fengli055@gmail.com, Lixin Tang

Motivated by practical applications in several industries, we study an integrated scheduling problem of production and energy consumption with submodular cost. In the problem, batch processing machine can process several jobs within its capacity limit simultaneously. In this paper, we propose an algorithm for solving the problem and carry out computational experiments to verify the performance of the algorithm.

■ TC13

13- Rivers

Alternate Direction Method in Non-Convex and Discrete Optimization

Cluster: Conic Programming

Invited Session

Chair: Jiming Peng, University of Houston, Industrial Engineering, Houston, TX, United States of America, jopeng@uh.edu

1 - An Integrated Approach to Non-convex QP: From Lagrangian Method to Modern Convex Relaxation

Jiming Peng, University of Houston, Industrial Engineering, Houston, TX, United States of America, jopeng@uh.edu

In this talk, we propose a new algorithm design framework for non-convex QP based on Lagrangian method and modern convex relaxation, which leads to novel alternate direction method (ADM). We characterize the convergence of the new ADMs in terms of a new notion the so-called approximate local optimal solution in optimization, and present several new optimization techniques that can help to locate the global optimal solutions to classes of non-convex QPs. Complexity of the new approach and its numerical performance will be discussed as well.

2 - Exact Augmented Lagrangian Dual for Mixed Integer Programming

Mohammad Javad Feizollahi, PhD Candidate, Georgia Institue of Technology, 755 Ferst Dr. NW, Atlanta, GA, 30332, United States of America, feizollahi@gatech.edu, Shabbir Ahmed, Andy Sun

We investigate augmented Lagrangian dual (ALD) for mixed integer programming (MIP) problems. We show that under mild assumptions, using any norm as a penalty function in ALD with a sufficiently large penalty coefficient closes the duality gap of MIPs. This approach is also able to recover a primal feasible solution. We also present an example where ALD with squared Euclidean norm penalty fails to close the duality gap for any finite penalty coefficient.

■ TC14

14- Traders

Eliciting the Wisdom of Crowds

Cluster: Game Theory

Invited Session

Chair: Shipra AgrawalResearcher, Microsoft Research, #9 Lavelle Road, Bangalore, 560025, India, shipra@microsoft.com

1 - Minimax Solutions, Random Playouts, and Perturbatons

Jacob Abernethy, Assistant Professor, Univ of Michigan, Ann Arbor, MI, 48109, United States of America, jabernet@umich.edu

In this talk we will explore the use of perturbation and randomization techniques for learning and decision-making. In particular, we will explore some nice connections between regularization methods commonly used in statistical learning and perturbation methods recently developed in online learning. The talk will also review some applications to problems in repeated games.

2 - Prediction Market Trading Strategies: Manipulation and Four Additional Price Misalignments

David Rothschild, Microsoft Research, 641 6th Ave., 7th FL, New York, NY, 10009, United States of America, davidmr@microsoft.com

Order books of real-money, election related prediction markets show persistent arbitrage opportunities. First, examining a randomized field trial of actual trades we demonstrate that arbitrage opportunities are significantly larger than the order book indicates. Second, examining transaction-level data for all trades (nearly 300,000 over 6,300 users) in one of the exchanges we present evidence suggestive of market manipulation by a single large trader. Third, we demonstrate four additional price misalignments resulting from biased trading and implicitly asymmetric trading costs. Finally, we explain how markets are still accurate, but also detail how to improve the information flow in prediction markets.

3 - Integrating Market Makers, Limit Orders, and Continuous Trade in Prediction Markets

Jennifer Wortman Vaughan, Researcher, Microsoft Research, 641 Avenue of the Americas, 7th Floor, New York, NY, 10011, United States of America, jenn@microsoft.com, David Pennock, Hoda Heidari, Sebastien Lahaie

We provide the first concrete algorithm for combining market makers and limit orders in a prediction market with continuous trade. Our mechanism handles bundle orders and arbitrary securities defined over combinatorial outcome spaces. We define the notion of an epsilon-fair trading path, a path in security space along which no order executes at a price more than epsilon above its limit, and every order executes when its market price falls more than epsilon below its limit. We show that under a supermodularity condition, a fair trading path exists for which the endpoint is efficient. We develop an algorithm for operating a continuous market maker with limit orders that respects the epsilon-fairness conditions even without supermodularity.

■ TC15

15- Chartiers

Bilevel Optimal Control

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Stephan Dempe, Department of Mathematics and, Computer Science, Freiberg, 09596, Germany, dempe@math.tu-freiberg.de

1 - Necessary Optimality Conditions for Optimal Control Problems with Equilibrium Constraints

Jane Ye, University of Victoria, Victoria, Canada, janeye@uvic.ca

We introduce and study the optimal control problem with equilibrium constraints (OCPEC). The OCPEC is an optimal control problem with mixed state and control constraints formulated as time dependent complementarity constraints. It provides a powerful modeling paradigm for many practical problems such as bilevel optimal control problems and dynamic principal-agent problems. In this paper, we propose Clarke (C-), Mordukhovich (M-), and strong (S-) stationary conditions and give some sufficient conditions under which a local minimizer is C-, M-, S- stationary. This is a joint work with Lei Guo.

2 - On a Special Bilevel Optimal Control Problem with Fully Convex Lower Level

Patrick Mehlitz, TU Bergakademie Freiberg, Prueferstrasse 1, Freiberg, 09596, Germany, mehlitz@math.tu-freiberg.de

In this talk a bilevel optimal control problem is considered whose upper and lower level problem are convex with respect to all variables while the dynamics are linear. Firstly, a formula is presented which allows the computation of the subdifferential of the lower level optimal value function by evaluating Pontryagin-type optimality conditions. The bilevel optimal control problem is transformed into a single-level optimal control problem possessing a DC-type objective functional (i.e. it equals the difference of two convex functionals) and linear dynamics. Finally, necessary optimality conditions are derived from the obtained surrogate problem using the aforementioned subdifferential formula and some results from DC-programming.

3 - The Natural Gas Cash-Out Problem: A Bilevel Optimal Control Approach

Francisco Benita, Tecnológico de Monterrey, Avenida Eugenio Garza Sada 2501 Sur, Monterrey, Mexico, francisco_benita@hotmail.com, Vyacheslav Kalashnikov, Patrick Mehlitz

The aim of this study is threefold: first it formulates the well-known natural gas cash-out problem as a bilevel optimal control problem; second it provides interesting theoretical results about Pontryagin-type optimality conditions for a general bilevle optimal control problem where the upper level posses a Mayer-type cost function, pure state constraints and the lower level is a binary-fine-dimnensional programming problem; and third, it applies these theoretical results in order to find local minimizers of the gas cash-out problem.

■ TC16

16- Sterlings 1

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Dieter Weninger, University Erlangen-Nürnberg, Department of Mathematics, Cauerstr. 11, Erlangen, 91058, Germany, dieter.weninger@math.uni-erlangen.de

1 - Dantzig-Wolfe Reformulations for the Maximum Weighted Independent Set Problem

Jonas Witt, RWTH Aachen, Operations Research, Kackertstr. 7, Aachen, D-52072, Germany, jonas.witt@rwth-aachen.de, Marco Lübbecke

Dantzig-Wolfe reformulation of an integer program partially convexifies a subset of the constraints, which yields an extended formulation with a potentially stronger linear programming (LP) relaxation than the original formulation. This presentation is part of an endeavor to understand the strength of such reformulations in general. We investigate Dantzig-Wolfe reformulations of the edge formulation for the maximum weighted independent set problem. In particular we characterize reformulations not yielding a stronger LP relaxation than the edge formulation and present necessary as well as sufficient conditions such that the reformulation is best possible.

2 - Decomposing MIPs by using Discontinuous Functions

Dieter Weninger, University Erlangen-Nürnberg, Department of Mathematics, Cauerstr. 11, Erlangen, 91058, Germany, dieter.weninger@math.uni-erlangen.de, Alexander Martin

We describe a variable decomposition algorithm which partitions the original problem into a number of subproblems, where the cut variables will be replaced by discontinuous functions. The corresponding polyhedra are determined by projection and sensitivity analysis. The polyhedra are refined until a global feasible solution can be obtained from the subproblems. This process can be further iterated to find a proven optimal solution. Computational results show the potential of this approach.

3 - Design and Measurement Issues for Magnetic Scales

Armin Fügenschuh, Helmut Schmidt University / University of the Federal Armed Forces Hamburg, Holstenhofweg 85, Hamburg, 22043, Germany, fuegenschuh@hsu-hh.de, Marina Ludszuweit, Marzena Fügenschuh, Alexandar Mojsic, Joanna Sokol

We deal with the design of a magnetic scale as an absolute positioning system. Trapezoid-shaped magnetic areas are placed side by side, so that the resulting pattern enables a unique encoding of each position up to a micrometer level. The problem of finding a longest-possible scale from a set of elementary magnetic areas is formulated as a linear mixed-integer problem. We solve it with a mixture of a heuristic and an exact approach. We approximate the magnetic signal using measured data from an array of Hall sensor cells, which mathematically leads to matrix factorization problems. From there, we discuss how the absolute position is recovered. Practical problems, such as measuring in an unknown altitude, are addressed.

■ TC17

17- Sterlings 2

Nonconvex, Non-Lipschitz, and Sparse Optimization I

Cluster: Nonlinear Programming

Invited Session

Chair: Zhaosong Lu, Associate Professor, Simon Fraser University, Department of Mathematics, Burnaby, Canada, zhaosong@sfu.ca

1 - Sparse Solutions of Linear Complementarity Problems

Xiaojun Chen, Professor, The Hong Kong Polytechnic University, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, xiaojun.chen@polyu.edu.hk, Shuhuang Xiang

This paper considers the characterization and computation of sparse solutions and least p-norm ($0 < p < 1$) solutions of the linear complementarity problems. We show that the number of non-zero entries of any least-p-norm solution of the LCP is less than or equal to the rank of the matrix M, and all least-p-norm solutions for sufficiently small p are sparse solutions. Moreover, we provide conditions on M such that a sparse solution can be found by solving convex minimization. Applications to the problem of portfolio selection within the Markowitz mean-variance framework are discussed.

2 - Convergence Analysis of L1 Greedy Method for Sparse Solution

Ming-Jun Lai, Professor, University of Georgia, Boyd Graduate Studies Building, Athens, GA, 30602, United States of America, mingjun.lai@gmail.com

I shall present an analysis of L1 greedy method for sparse solution of underdetermined linear systems. The L1greedy method was proposed by Petukhov and his collaborator in 2012. Although it is not the most efficient method, it is an very accurate method. Numerical results will be demonstrated to show the accuracy by comparing it with many algorithms including the re-weighted L1 algorithm, hard thresholding pursuit algorithms (HTP), approximate message passing (AMS) algorithms, generalized AMS (GAMP) algorithm and etc.. A few attempts for speeding up the L1 greedy algorithm will be discussed.

3 - A Second-Order Method for Convex L1-Regularized Optimization with Active Set Prediction

Nitish Shirish Keskar, Northwestern University, 2145 Sheridan Road, Room C210, Evanston, IL, 60208, United States of America, nitishkeskar2012@u.northwestern.edu, Figen Oztoprak, Andreas Waechter, Jorge Nocedal

We describe an active-set method for minimizing an L1-regularized smooth convex function. At every iteration, the algorithm selects a candidate set of free and fixed variables and computes a trial step using an (inexact) subspace phase. If its quality is not acceptable, the set of free variables is restricted and the trial point is recomputed. We establish global convergence for our approach and compare the method against the state-of-the-art code LIBLINEAR.

■ TC18

18- Sterlings 3

Recent Advances in Simulation Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Enlu Zhou, School of Industrial & Systems Engineering, Georgia Institute of Technology, Atlanta, GA, United States of America, enlu.zhou@isye.gatech.edu

1 - Stratified Bayesian Optimization

Saul Toscano, Cornell University, 283 Rhodes Hall, Ithaca, NY, 14850, United States of America, st684@cornell.edu, Peter Frazier

We consider simulation optimization, and noisy derivative-free optimization of expensive functions, when most of the randomness in the objective is produced by a few influential scalar random inputs. We present a new Bayesian global optimization algorithm, called Stratified Bayesian Optimization (SBO), which uses this strong dependence to improve performance. Our algorithm is similar in spirit to stratification, a classical technique from simulation, which uses strong dependence on a categorical representation of the random input to reduce variance.

2 - Reconstructing Input Models via Simulation Optimization

Henry Lam, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, United States of America, khlam@bu.edu, Alexandrina Goeva, Bo Zhang

We consider the problem of calibrating a stochastic input model from data that is only available indirectly as the "output" of some system. This arises in service operations when data is observable only at an aggregate level. Taking a nonparametric perspective, we post a maximum entropy formulation that matches the simulation to empirical outputs, in order to recover the most natural input model that respects the data. We investigate approximate solutions to these optimizations, which typically possess non-convex stochastic constraints, by reducing them into sequences of non-convex optimizations with stochastic objectives but convex deterministic constraints, which are subsequently locally solvable by stochastic feasible direction methods.

3 - Simulation Optimization under Input Uncertainty

Enlu Zhou, School of Industrial & Systems Engineering, Georgia Institute of technology, Atlanta, GA, United States of America, enlu.zhou@isye.gatech.edu

Stochastic simulation is driven by input model, which is a collection of distributions that model the randomness in the system. Input model is often constructed from data, and hence input uncertainty arises due to the finiteness of data. Simulation optimization has been mostly studied under the assumption of a fixed input model, without accounting for the uncertainty of input model. We propose a new framework to study simulation optimization under input uncertainty. This framework can be viewed as a generalization of distributional robust optimization (DRO). We will then outline numerical methods and challenges in solving this framework.

■ TC19

19- Ft. Pitt

Hybrid Optimization II

Cluster: Constraint Programming

Invited Session

Chair: Michele Lombardi, DISI, University of Bologna, Viale del Risorgimento 2, Bologna, 40136, Italy, michele.lombardi2@unibo.it

1 - A Polyhedral Approach to the Chordal Completion Problem

David Bergman, University of Connecticut, United States of America, david.bergman@business.uconn.edu

The minimum chordal completion problem is the classical optimization problem of finding, on a simple undirected graph, the fewest number of edges necessary to add to the graph so that the largest induced cycle has length 3. Although the problem is simple to pose and has been considered for decades, few computational approaches have been attempted and research has focused primarily on heuristics. In this talk a integer programming approach to the problem is presented based on a polyhedral analysis of the convex hull of feasible solutions. Computational testing shows that the approach outperforms existing techniques.

2 - Lagrangian Relaxation Based on Decision Diagrams

Andre Augusto Cire, Assistant Professor, University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C1A4, Canada, acire@utsc.utoronto.ca, David Bergman, Willem-Jan van Hoeve

A new research stream in optimization considers the use of multivalued decision diagrams (MDDs) to encode discrete relaxations of combinatorial optimization problems. In this talk we discuss how to strengthen an MDD relaxation by incorporating dual information in the form of Lagrangian multipliers into its cost structure. Computational experiments on scheduling problems indicate that this technique can improve solving times substantially when compared to other generic-purpose methods.

3 - Master/Slave Scheme for the Multi-Item, Multi-Plant and Multi-Capacity Lot-Sizing Problem

Samuel Deleplanque, ULB, Campus de la Plaine, NO, Bruxelles, Belgium, deleplanque.samuel@gmail.com, Enrico Gorgone, Safia Kedad Sidhoum, Alain Quilliot

We present a multi-item, multi-plant, multi-period Lot-Sizing Problem with Setup production times and multi-capacities. The problem consists of satisfying all the demand according to the production, the transfer and the storage capacities. The optimal solution will minimize the total cost (fixed and variable production costs, transfer cost and storage cost). The problem with capacities is NP-HARD. We established a Master/Slave resolution scheme based on a Lagrangian-based heuristic with a relaxation of all the capacities.

■ TC20

20- Smithfield

Algorithms in Nonsmooth and Nonconvex Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Milagros Loreto, Assistant Professor, University of Washington Bothell, 2575 NE Northstar, Issaquah, Wa, 98029, United States of America, Mloreto@uwb.edu

1 - On the Directional Derivative of Optimal Value Functions of Nonsmooth Convex Problems

Robert Mohr, Karlsruhe Institute of Technology, Degenfeldstrafle 5-9, Apartment 04.03.11, Karlsruhe, 76131, Germany, robert.mohr@kit.edu, Oliver Stein

We present a formula for the directional derivative of the optimal value function of a nonsmooth and completely convex parametric problem. The formula is valid at boundary points of the domain of the optimal value function if the direction belongs to a certain conic set. We derive a functional description for this conic set and apply the formula to selected convex problems such as convex semi-infinite problems or problems involving sums and maxima of norms.

2 - Convergence of a Nonconvex Bundle Method for Constrained Optimization

Minh Ngoc Dao, Dr, Hanoi National University of Education and University of British Columbia Okanagan, 3333 University Way, Kelowna, BC, V1V 1V7, Canada, minhdn@hnue.edu.vn

This work considers inequality constrained optimization problems on a closed convex subset of a finite dimensional real space, where the objective and constraints are described by real-valued locally Lipschitz but not necessarily smooth or convex functions. We use a progress function to handle the presence of constraints and propose a nonconvex bundle method based on downshifted tangents and a suitable backtracking strategy, which assures a global convergence for important classes of nonsmooth functions in applications.

3 - Modified Spectral Projected Subgradient Method (MSPS)

Milagros Loreto, Assistant Professor, University of Washington Bothell, 2575 NE Northstar, Issaquah, Wa, 98029, United States of America, Mloreto@uwb.edu, Alejandro Crema

A Modified version of the Spectral Projected Subgradient (MSPS) is presented. The MSPS is the result of applying to SPS the direction approach used by Spectral Projected Gradient version one (SPG1) proposed by Raydan et al. MSPS presents stronger convergence properties than SPS. We give a comprehensive theoretical analysis of the MSPS and its convergence is shown under some mild assumptions. To illustrate its behavior, we present and discuss numerical results for set covering problems.

■ TC21

21-Birmingham

Algorithms for Optimization with Structural Ambiguity

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Guanghui Lan, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, United States of America, glan@ise.ufl.edu

1 - Extending the Scope of Uniformly Optimal Methods for General Nonlinear Programming

Saeed Ghadimi, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, United States of America, sghadimi@ufl.edu, Guanghui Lan

We develop a generic framework to extend uniformly optimal convex programming algorithms to general nonlinear programming. Without requiring any problem parameters, these algorithms achieve the best known complexity for nonconvex problems, and the optimal complexity for convex ones. In particular, for the first time in the literature, we show that the level-type algorithms can be used for solving nonconvex problems uniformly.

2 - Adaptive Sampling for Simulation Optimization and Stochastic Root Finding

Raghu Pasupathy, Purdue University, pasupath@purdue.edu, Sara Shashaani

For roughly six decades since Robbins and Monro (1951), Stochastic Approximation has dominated the landscape of algorithms for root finding and optimization problems with Monte Carlo observable functions. Recently, however, there has been increasing interest in sampling-based frameworks where an existing recursive method, e.g., quasi-Newton or trust-region recursion, is embedded with Monte Carlo estimators of objects within the recursion. We consider the question of how to adaptively sample within such stochastic recursions. We demonstrate that a simple adaptive scheme that has connections to proportional-width sequential confidence intervals endows stochastic recursions with near-optimal convergence rates.

3 - Parallel Bayesian Global Optimization, with Application to Metrics Optimization at Yelp

Jialei Wang, Cornell University, Rhodes Hall, 292, Ithaca, NY, 14853, United States of America, jw865@cornell.edu, Scott Clark, Eric Liu, Peter Frazier

We consider parallel global optimization of expensive-to-evaluate functions, and propose an efficient method based on stochastic approximation for implementing a conceptual Bayesian optimization algorithm proposed by Ginsbourger et al. (2010). We also introduce an open-source software implementation of this algorithm, called Metrics Optimization Engine, developed in collaboration with engineers at Yelp, Inc. and used internally at Yelp to optimize prediction models and performance metrics.

■ TC22

22- Heinz

Novel Cuts for MINLP

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: James Luedtke, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53706, United States of America, jrluedt1@wisc.edu

1 - Intersection Cuts for Convex Integer Programs from Translated Cones

Umakanta Pattanayak, Research Scholar, IIT Bombay, IIT Bombay, Powai, Mumbai, MH, 400076, India, umakanta@iitb.ac.in, Vishnu Narayanan

We develop a general framework for intersection cuts for convex integer programs by studying integer points of the associated translated tangent cones. For proper translated cones, under certain mild conditions all intersection cuts are valid for the integer hull, and conversely a large class of valid inequalities are indeed intersection cuts, computable via polyhedral approximations. Finally, valid inequalities for non-pointed translated cones can be derived as intersection cuts for associated proper translated cones.

2 - Convex Nonlinear Relaxations of the Pooling Problem

James Luedtke, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53706, United States of America, jrluedt1@wisc.edu, Jeff Linderoth, Claudia D'Ambrosio

We investigate relaxations for the non-convex pooling problem, which arises in production planning problems in which products with are mixed in intermediate "pools" in order to meet quality targets at their destinations. We derive valid nonlinear convex inequalities, which we conjecture define the convex hull of this continuous non-convex set for some special cases. Numerical illustrations of the results will be presented.

3 - Perspective Cuts Revolution

Hassan Hijazi, Dr., NICTA, 7 London Circuit, Canberra, Australia, hassan.hijazi@nicta.com.au

This talk will cover recent advances in the application of perspective cuts for convexifying bilinear functions and quadratic on/off constraints.

■ TC23

23- Allegheny

Primal-Dual and Proximal Methods in Sparse Optimization II

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Stephen Becker, Assistant Professor, University of Colorado Boulder, 526 UCB, University of Colorado, Boulder, CO, 80309, United States of America, Stephen.Becker@colorado.edu

1 - A Hybrid Quasi-Newton Projected-Gradient Method with Application to Lasso and Basis-Pursuit Denoise

Ewout van den Berg, IBM Watson, 1101 Kitchawan Rd., Yorktown Heights, NY, 10598, United States of America, evandenberg@us.ibm.com

In this talk I present a new algorithm for the optimization of convex functions over a polyhedral set. The algorithm is a hybrid of the spectral projected-gradient and quasi-Newton methods in which the type of step is determined dynamically at each iteration. Practical applications of the framework include the Lasso problem, which also appears as a subproblem in the basis-pursuit denoise solver SPGL1, as well as bound-constrained least squares. Experimental results on these problems will be presented.

2 - Designing Statistical Estimators that Balance Sample Size, Risk, and Computational Cost

John Bruer, California Institute of Technology, 1200 E California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, jbruer@cms.caltech.edu, Joel Tropp, Volkan Cevher, Stephen Becker

In this talk, we propose a tradeoff between computational time, sample complexity, and statistical accuracy that applies to statistical estimators based on convex optimization. When we have a large amount of data, we can exploit excess samples to decrease statistical risk, to decrease computational cost, or to trade off between the two. We propose to achieve this tradeoff by varying the amount of smoothing applied to the optimization problem. To develop these ideas, we use regularized linear regression as a case study. We present theoretical and numerical results that show the existence of such a tradeoff. We illustrate its use in an image interpolation problem.

3 - A Conjugate Interior Point Approach for Large-Scale Problems

Alexandr Aravkin, IBM T.J. Watson Research Center, 1101 Kitchawan Rd., Yorktown Heights, NY, 10598, United States of America, sasha.aravkin@gmail.com

Many important applications can be formulated as large-scale optimization problems, including classification in machine learning, data assimilation in weather prediction, inverse problems, and medical and seismic imaging. While first-order methods have proven widely successful in recent years, recent developments suggest that matrix-free second-order methods, such as interior-point methods, can be competitive. We develop a modeling framework for a wide range of problems, and show how conjugate representations can be exploited to design a uniform interior point approach for this class. We then show several applications, with emphasis on modeling and problem structure.

■ TC24

24- Benedum

MINLP: Non-Standard Approaches and Applications I

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Victor Blanco, Universidad de Granada, Facultad de CC Economicas, Granada, Spain, vblanco@ugr.es

1 - Heuristics based on Test-Sets for Reliability-Allocation Problems

Isabel Hartillo, Universidad de Sevilla, Dpto. Matematica Aplicada I, Sevilla, Spain, hartillo@us.es, Jes˙s Gago-Vargas, Justo Puerto, Jose M Ucha

The reliability allocation problem for series-parallel homogeneous multi-state systems uses redundancy of components with different levels of performance in order to achieve a fixed reliability minimizing its cost. This problem has been treated with different heuristic methods as Genetic Algorithm, Tabu Search or Ant Colony Optimization. In our approach we use the skeleton given by a test set obtained from a linear subproblem. This algebraic technique has been used as exact method for the one state case. We use an Ant Colony Optimization algorithm to solve several instances of the problem.

2 - New Algebraic Approach to Multi-Objective Linear Integer Programming

Jose M Ucha, Universidad de Sevilla, Dpto. Algebra, Sevilla, Spain, ucha@us.es, Jesus Gago-Vargas, Isabel Hartillo, Haydee Jiménez

We propose an algebraic alternative to the partial Gröbner bases to deal with multi-objective linear integer programming problems. Using a classical epsilon-constraint strategy, we provide an approach that uses the classical Grˆbner bases to compute a test-set for one objective problems. In the bi-objective case, the computation of the complete Pareto optima set can be done essentially in a single process of reduction/division.

3 - A MINLP Multi-Criteria Optimization for the Aircraft Conflict Resolution Problem

F. Javier Martìn-Campo, Universidad Complutense de Madrid, Campus de Somosaguas, Pozuelo de Alarcon (Madrid), Spain, javier.martin.campo@ccee.ucm.es, Antonio Alonso-Ayuso, Laureano F. Escudero

A mixed integer nonlinear optimization model for the aircraft conflict resolution problem is presented. The aim of the problem consists of providing a configuration for a set of aircraft sharing the same air sector, such that every aircraft does not violate the safety distances with respect to the others. Three different optimization objectives are considered into a multi-criteria framework. A broad computational experiment is presented to assess the validity of the proposal.

■ TC25

25- Board Room

Optimization Methods in Pricing and Supply Chains

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Georgia Perakis, MIT, 100 Main Street, Cambridge, MA, United States of America, georgiap@mit.edu

1 - Scheduling Promotion Vehicles to Boost Revenues: A Provably-Good Analytical Approach

Lennart Baardman, MIT, Operations Research Center, Cambridge, MA, 02139, United States of America, baardman@mit.edu, Maxime Cohen, Kiran Panchamgam, Georgia Perakis, Danny Segev

Retailers use promotion vehicles (e.g. flyers, commercials etc.) to increase revenues. We model how to assign promotion vehicles to maximize revenues as an NLIP. The problem is proven to be NP-hard, and even hard to approximate. However, we construct an epsilon-approximation in the form of an IP of polynomial size. Also, we propose a greedy algorithm with a provable guarantee and on average near-optimal performance. Finally, using supermarket data we show our models can lead to a significant increase in revenues.

2 - A Graph Theoretic Way of Dynamic Pricing

Swati Gupta, Graduate Student, Operations Research Center, MIT, 77 Massachusetts Avenue, E40-149, Cambridge, United States of America, swatig@mit.edu, Georgia Perakis, Maxime Cohen, Jeremy J Kalas

We introduce a class of dynamic programs for multi-period multi-item pricing problems based on an equivalent graphical reformulation that can handle naturally various business rules that arise in practice while providing access to a wide range of ideas from combinatorial optimization. We consider demand models that capture the stockpiling behavior of consumers through dependence on past prices. For fixed memory, we propose a polynomial time algorithm but also illustrate that when the memory is large the problem is NP-hard. We then propose an FPTAS algorithm for the linear reference price demand model. Finally, we extend our results to capture cross-item effects using the notion of a single "virtual" competitor item.

3 - Robust Newsvendor Facing Mixed Demand

Daniel Chen, MIT, 77 Massachusetts Avenue, E40-112, Cambridge, MA, United States of America, dcchen@mit.edu, Retsef Levi, Georgia Perakis

In the newsvendor model, the goal is to determine an optimal inventory level facing uncertain demand and linear shortage and oversupply costs. Traditionally, full knowledge of the demand distribution is assumed, but this is unrealistic in practical scenarios. We model partial information by modeling demand as a mixture of known distributions with unknown weights and formulate the problem using robust optimization. Our proposed solution is tractable and uses this mixture structure in a robust manner. We use data to construct uncertainty sets and derive a bound on the probability of these sets containing the true distribution. This works well in computational experiments, even when the number of samples from the true distribution is small.

■ TC26

26- Forbes Room

Selected Topics in Stochastic Programming Applications

Cluster: Stochastic Optimization

Invited Session

Chair: Ruediger Schultz, University of Duisburg-Essen, Thea-Leymann-Strasse 9, Essen, Germany, ruediger.schultz@uni-due.de

1 - Worst Case Analysis of Noxious Substance Impact on Fish Metabolism

Judith Klein, M.Sc., University of Duisburg-Essen, Faculty of Mathematics, Thea-Leymann-Str. 9, Essen, 45127, Germany, judith.klein@uni-due.de, Ruediger Schultz, Christian Schlechtriem

Exposure of fish feed to noxious substances is a critical issue in fish farming. The talk deals with the two different aquaculture species Rainbow Trout (Oncorhynchus mykiss) and Common Carp (Cyprinus carpio). In particularly pesticide residues being uncertained, stochastic programming approaches, both risk neutral and risk averse, are investigated. Preliminary computational results is reported.

2 - Stochastic Semidefinite Programming for Unit Commitment Under Uncertainty

Tobias Wollenberg, Dipl.-Math., University of Duisburg-Essen, Faculty of Mathematics, Thea-Leymann-Str. 9, Essen, 45127, Germany, tobias.wollenberg@uni-due.de, Ruediger Schultz

This talk will address unit commitment under uncertainty of load in alternating current (AC) power systems. The presence of uncertain data leads us to (risk averse) two-stage stochastic programs. To solve these programs to global optimality a recent semidefinite programming approach to the optimal power flow problem is used. This results in specific mixed integer semidefinite stochastic programs for which a decomposition algorithm is presented.

■ TC27

27- Duquesne Room

Intermittent Resources and Demand Response II

Cluster: Optimization in Energy Systems

Invited Session

Chair: Alfredo Garcia, Professor, Department of Industrial and Systems Engineering, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611-6595, United States of America, alfredo.garcia@ufl.edu

1 - Robust Chance Constrained Optimization in Electricity Networks with Ramping Constraints

Luis Zuluaga, Lehigh University, Mohler Lab Room 387, 200 West Packer Avenue, Bethlehem, PA, 18015, United States of America, luis.zuluaga@lehigh.edu, Alberto Lamadrid, Mohsen Moarefdoost

We study the ramping costs and generation constraints in power networks in which renewable energy is the main source of uncertainty. A robust chance constrained optimization model is developed to design dispatch policies that manage the risk and maintain system reliability. Such model can be written using SOCP constraints for typical renewable power probability distributions. This model is compared in terms of efficiency with the stochastic programming formulation of the chance constraints using sampling techniques.

2 - A Polyheral Study of Multistage Stochastic Unit Commitment Polytope

Kai Pan, PhD Student, University of Florida, 411 Weil Hall, Gainesville, FL, 32611, United States of America, kpan@ufl.edu, Yongpei Guan

In this paper, we investigate a multistage stochastic integer programming formulation for the unit commitment problem under uncertainty. A scenario tree based deterministic equivalent formulation is provided, which leads to a large-scale mixed integer linear program (MILP). By exploring its polyhedral structure, several families of strong valid inequalities are generated. In particular, we obtain convex hull presentations for certain special cases and facets for the general polytope. Finally, the computational results verify the effectiveness of the proposed cutting planes.

■ TC28

28- Liberty Room

Advances in Global Optimisation

Cluster: Global Optimization

Invited Session

Chair: Ruth Misener, Lecturer and RA Eng. Research Fellow, Imperial College London, South Kensington Campus, London, SW7 2AZ, United Kingdom, r.misener@imperial.ac.uk

1 - Global Optimization of Genenal Constrained Grey Box Models

Christodoulos Floudas, Professor and Director, Texas A&M Energy Institute, Texas A&M University, 302D Williams Administration Bldg., 3372 Texas A&M University, College Station, TX, 77843, United States of America, floudas@tamu.edu

A novel methodology for the global optimization of general constrained grey-box models is introduced. The key components of (a) sampling reduction, (b) identification of best surrogate functions for the objective function and constraints, (c) global optimization for the parameter estimation of each surrogate function, (d) global optimization of the resulting composite constrained grey-box approximation problem, and (e) updating of bounds via clustering, are discussed. Computational studies on challenging constrained grey-box models, and comparisons to existing approaches are presented.

2 - A Decomposition Algorithm for Two-Stage Stochastic Mixed-Integer Nonconvex Programs

Paul Barton, Professor, MIT, 66-470b, 77 Massachusetts Avenue, Cambridge, MA, United States of America, pib@mit.edu, Rohit Kannan

Two-stage stochastic mixed-integer nonconvex programs have found a wide range of applications in the design and operation of engineering systems. In this work, a decomposition-based branch-and-bound algorithm, which relies on Lagrangian duality and nonconvex generalized Benders decomposition (NGBD) for the lower bounding problem, and aggressive bounds tightening for obtaining tight variable bounds, is proposed. The computational advantages of the proposed algorithm over state-of-the-art global optimization software and the conventional Lagrangian relaxation algorithm are demonstrated through case studies using a recently-developed open-source utility for two-stage stochastic nonconvex programs.

■ TC29

29- Commonwealth 1

Tensor Recovery, Decomposition and Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Shiqian Ma, Assistant Professor, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, William M.W.Mong Engineering Building, Shatin, N.T., Hong Kong - PRC, sqma@cuhk.edu.hk

Co-Chair: Shuzhong Zhang, Professor, University of Minnesota, Department of Industrial and Systems Eng, Minneapolis, MN, 55455, United States of America, zhangs@umn.edu

1 - Large Scale Eigenvalue Computation Using Tensor-train Format

Zaiwen Wen, Beijing International Center for Mathematical Research, Peking University, No. 5 Yiheyuan Road, Haidian District, Beijing, 100871, China, wenzw@math.pku.edu.cn

In this talk, we present an efficient approach for finding the p smallest eigenvalues and their associated eigenvectors represented in a prescribed tensor-train (TT) format by solving the trace-minimization problem for a given a huge symmetric matrix A.

2 - Higher-Order Singular Value Decomposition from Incomplete Data

Yangyang Xu, Postdoctoral Fellow, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, yangyang.xu@uwaterloo.ca

Higher-order singular value decomposition (HOSVD) is an efficient way for data reduction and also eliciting intrinsic structure of multi-dimensional array data. It has been used in many applications, and some of them involve incomplete data. I will talk about an incomplete HOSVD problem, which simultaneously achieves imputation of missing values and also tensor decomposition. With a rank-increasing strategy, the alternating minimization method is found very efficient to solve the problem. Numerical results on tensor face recognition and low-rank tensor recovery will be presented.

3 - Successive Rank-One Approximations of Nearly Orthogonally Decomposable Symmetric Tensors

Cun Mu, PhD Student, IEOR, Columbia University, 500 West 120th Street, New York, NY, 10027, United States of America, cm3052@columbia.edu

Many idealized problems in signal processing, machine learning and statistics can be reduced to the problem of finding the symmetric canonical decomposition of an underlying symmetric and orthogonally decomposable (SOD) tensor. Drawing inspiration from the matrix case, the successive rank-one approximations (SROA) scheme has been proposed and shown to yield this tensor decomposition exactly, and many numerical methods have thus been developed for the tensor rank-one approximation problem. In practice, however, the input tensor can only be assumed to be a nearly SOD tensor. This article shows that even in the presence of perturbation, SROA can still robustly recover the symmetric canonical decomposition of the underlying tensor.

■ TC30

30- Commonwealth 2

Approximation and Online Algorithms VI

Cluster: Approximation and Online Algorithms

Invited Session

Chair: David Shmoys, Cornell University, 231 Rhodes Hall, Ithaca, NY, United States of America, david.shmoys@cornell.edu

1 - An Experimental Evaluation of the Best-of-Many Christofides' Algorithm for the Traveling Salesman Problem

David Williamson, Professor, Cornell University, 236 Rhodes Hall, Ithaca, NY, 14850, United States of America, dpw@cs.cornell.edu, Kyle Genova

Recent papers on approximation algorithms for the traveling salesman problem (TSP) have given a new variant on the well-known Christofides' algorithm for the TSP, called the Best-of-Many Christofides' algorithm. The algorithm involves sampling a spanning tree from the solution the standard LP relaxation of the TSP; one then runs Christofides' algorithm on the resulting tree. We perform an experimental evaluation of several variants the Best-of-Many Christofides' algorithm. In our experiments, all of the implemented methods perform significantly better than the Christofides' algorithm; an algorithm that samples from a maximum entropy distribution over spanning trees seems to be particularly good.

2 - A Logarithmic Additive Integrality Gap for Bin Packing

Rebecca Hoberg, University of Washington, Seattle, WA, United States of America, rahoberg@math.washington.edu, Thomas Rothvoss

For bin packing, the input consists of n items with sizes s1,...,sn?[0,1] which have to be assigned to a minimum number of bins of size 1. Recently, the second author gave an LP-based polynomial time algorithm that employed techniques from discrepancy theory to find a solution using at most OPT+O(logOPT∑loglogOPT) bins. In this paper, we present an approximation algorithm that has an additive gap of only O(logOPT) bins, which matches certain combinatorial lower bounds. Any further improvement would have to use more algebraic structure. Our improvement is based on a combination of discrepancy theory techniques and a novel 2-stage packing: first we pack items into containers; then we pack containers into bins of size 1. Apart from being more effective, we believe our algorithm is much cleaner than the one of Rothvoss.

3 - Algorithms and Computational Results for the (Citi) Bike-Sharing System

David Shmoys, Cornell University, 231 Rhodes Hall, Ithaca, NY, United States of America, david.shmoys@cornell.edu, Eoin O'Mahony

New York launched the largest bike-sharing system in North America in May 2013. We have worked with Citibike, using analytics and optimization to change how they manage the system. Huge rush-hour usage imbalances the system; we answer the questions of where should bikes be before then and how to get them there? Pre-balancing the system in preparation for usage requires placement of the available bikes at stations to minimize the expected rush-hour outage minutes. We use continuous-time Markov chains combined with integer programming models to find the best placement. Achieving this requires trucking bikes around NYC overnight; to find the best routes we use integer programming models combined with observations about submodular structure.

Tuesday, 2:45pm - 4:15pm

■ TD01

01- Grand 1

Distributed Memory Algorithms/Exact Algorithms

Cluster: Implementations and Software

Invited Session

Chair: Deepak Rajan, Computer Scientist, Lawrence Livermore National Laboratory, P.O. Box 808, L-495, Livermore, CA, 94551, United States of America, rajan3@llnl.gov

1 - A Parallel Implementation of a Scenario Decomposition Algorithm for Stochastic 0-1 Programs

Kevin Ryan, Georgia Institute of Technology, 755 Ferst Drive, Atlanta, United States of America, kryan31@gatech.edu, Deepak Rajan, Shabbir Ahmed

A recently proposed scenario decomposition algorithm for stochastic 0-1 programs finds an optimal solution by evaluating and removing individual solutions discovered by solving scenario subproblems. In this work, we develop an asynchronous parallel implementation of the algorithm. We test the results on well known stochastic 0-1 programs and large scale stochastic optimization problems from the electric grid. New improvements to accelerate the original algorithm using local search and cutting planes are also presented.

2 - Distributed Memory B&B for Stochastic MIPs using Distributed Memory Simplex for Stochastic LPs

Geoffrey Oxberry, Postdoctoral Research Associate, Lawrence Livermore National Laboratory, P.O. Box 808, L-792, Livermore, CA, 94551, United States of America, oxberry1@llnl.gov, Cosmin Petra, Pedro Sotorrio, Deepak Rajan, Thomas Edmunds

Stochastic MIPs with large numbers of scenarios can easily result in deterministic equivalent formulations that exceed available memory on a single workstation. In such situations, one must distribute problem data over many computers; however, doing so requires reformulating existing serial algorithms to execute in parallel. Here, we describe a proof-of-concept distributed memory implementation of branch-and-bound with results for small stochastic MIPs, and discuss a path forward to solving much larger stochastic unit commitment problem instances.

3 - Efficient Update Algorithms for the Roundoff-Error-Free LU and Cholesky Factorizations

Adolfo Escobedo, PhD Candidate, Texas A&M University, 3131, TAMU, College Station, TX, 77843, United States of America, adolfoescobedo@tamu.edu, Erick Moreno-Centeno

We introduce efficient update algorithms for the Roundoff-error-free (REF) LU and Cholesky factorizations. The update operations are addition, deletion, and replacement of rows and columns of a basis. Combined with REF forward and backward substitution, the featured algorithms provide a complete framework for solving linear programs exactly and efficiently. A significant advantage of the REF linear programming framework is that the length of any coefficient calculated via its associated algorithms is bounded polynomially without having to use gcd operations.

■ TD02

02- Grand 2

Optimization in Energy Systems I

Cluster: Optimization in Energy Systems

Invited Session

Chair: Victor Zavala, Computational Mathematician, Argonne National Laboratory, 9700 South Cass Ave, Argonne, IL, 60439, United States of America, vzavala@mcs.anl.gov

1 - Multiperiod MINLP Model for Long-Term Shale Gas Development

Markus Drouven, PhD Student, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA, United States of America, mdrouven@andrew.cmu.edu, Ignacio Grossmann

In this work we address the long-term shale gas development problem which involves determining the optimal development schedule for drilling and fracturing gas wells, and designing the pipelines and natural gas plants for the gathering infrastructure. This problem is formulated as a large-scale nonconvex MINLP involving concave investment cost expressions and bilinear terms for the flow balances for the components in the gas stream. We describe a solution strategy that relies on an MILP approximation that is coupled with a restricted MINLP, and which yields near optimal global solutions. We present results for some real world applications, which show the large economic savings that can be achieved.

2 - New Formulations and Valid Inequalities for the Optimal Power Flow Problem

Andy Sun, Assistant Professor, Georgia Institute of Technology, 765 Ferst Drive, Room 444 Groseclose Bld., Atlanta, GA, 30332, United States of America, andy.sun@isye.gatech.edu, Santanu Dey, Burak Kocuk

The optimal power flow (OPF) problem is a fundamental problem in electric power systems operations, and is a challenging nonconvex quadratic optimization problem. In this talk, we will present algorithmic techniques for finding globally optimal solutions of OPF. We begin by presenting a new formulation for the OPF problem and prove that the McCormick relaxation of the new formulation is stronger than that of the classic formulation. We study the qualities of several other relaxations based on SOCP and SDP. Then, we present a class of valid inequalities for the new formulation. Finally, we present extensive computational results to compare the new formulation and valid inequalities against the performance of the classical formulation.

3 - On the Role of Wind Correlation in Power Grid Economic Dispatch Operations

Cosmin Petra, Argonne National Laboratory, 9700 South Cass Avenue, Lemont, IL, 60439, United States of America, petra@mcs.anl.gov

We study the impact of capturing spatiotemporal correlations between multiple wind supply points on economic dispatch procedures. We show analytically that over/underestimation of correlation leads to positive and negative biases of dispatch cost, respectively. Then a large-scale computational study for the State of Illinois transmission grid with real topology and physical constraints is performed by using the interior-point solver PIPS-IPM on the BG/Q supercomputer at Argonne National Laboratory. We find that strong and persistent cost and price biases result from neglecting correlation information and indicate to the need of coordinating weather forecasts and uncertainty characterizations for wind power producers.

■ TD03

03- Grand 3

Network Design I

Cluster: Combinatorial Optimization

Invited Session

Chair: Laura Sanita, University of Waterloo, 200 University Ave W, Waterloo, Canada, laura.sanita@uwaterloo.ca

1 - Local Search Heuristics for Mobile Facility Location Problems

Zachary Friggstad, University of Alberta, 3-06 Athabasca Hall, University of Alberta, Edmonton, AB, T6G 2E8, Canada, zacharyf@cs.ualberta.ca, Chaitanya Swamy, Sara Ahmadian

In the Mobile Facility Location problem, a collection of facilities are already placed at locations throughout a metric space. They may be moved to new locations at a cost. The goal is to move these facilities in a way that minimizes their total movement cost plus the total cost of connecting each client to some new facility location. We present a 3+eps approximation for this problem based on local search, improving over the previous LP-based 8-approximation. The local search algorithm that tries to move a few facilities at a time can produce very expensive solutions. Our improvement comes by ensuring we always maintain an optimal matching between facilities and their destinations at each step of the local search procedure.

2 - A (1 + e)-Embedding of Low Highway Dimension Graphs into Bounded Treewidth Graphs

Andreas Feldmann, University of Waterloo, 200 University Avenue West, Waterloo, ON, Canada, andreas.feldmann@uwaterloo.ca, Jochen Koenemann, Wai Shing Fung, Ian Post

Graphs with bounded highway dimension were introduced by Abraham et al. as a model of transportation networks. We show that any such graph can be embedded into a bounded treewidth graphs with arbitrarily small distortion: if the highway dimension of G is constant we show how to compute a subgraph of the shortest path metric of a graph G with the following two properties. It distorts the distances of G by a factor of 1 + e in expectation and has a treewidth that is polylogarithmic in the aspect ratio of G. In particular, this result implies quasi-polynomial time approximation schemes for a number of optimization problems that naturally arise on transportation networks, including Travelling Salesman, Steiner Tree, and Facility Location.

3 - Finding Small Stabilizers for Unstable Graphs

Karthekeyan Chandrasekaran, University of Illinois, Urbana-Champaign, 104 S. Mathews Ave, 301, Transportation Building, Urbana, IL, 61801, United States of America, karthe@gatech.edu, Laura Sanita, Jochen Koenemann, Adrian Bock, Britta Peis

An undirected graph G is stable if its inessential vertices (those that are exposed by at least one maximum matching) form a stable set. Stable graphs play an important role in cooperative game theory. In this work, we focus on the following edge-deletion problem: given a graph G, can we find a minimum cardinality subset of edges whose removal yields a stable graph? We show that the removal of any such minimum cardinality subset of edges does not decrease the cardinality of the maximum matching in the graph. We further show that the problem is vertex-cover hard and also develop efficient approximation algorithms for sparse graphs and for regular graphs. Based on joint work with Adrian Bock, Jochen Koenemann, Britta Peis and Laura Sanita.

■ TD04

04- Grand 4

First-Order Methods for Structured and/or Conic Optimization – Part I

Cluster: Conic Programming

Invited Session

Chair: Robert Freund, Professor, MIT Sloan School of Mgmt., 77 Massachusetts Ave., Cambridge, MA, 02139, United States of America, rfreund@mit.edu

1 - Low-rank Matrix and Tensor Recovery: Theory and Algorithms

Donald Goldfarb, Professor, Columbia University, IEOR Department, 500 West 120th St., New York, NY, 10027, United States of America, goldfarb@columbia.edu, Zhiwei (Tony) Qin, Cun Mu, Bo Huang, John Wright

For problems in which the intrinsic structure of incomplete or corrupted data is more than 3-dimensional, low-rank completion and RPCA convex models for matrices have been extended to tensors. Here we establish recovery guarantees for both tensor completion and tensor RPCA, show that using the most popular convex relaxation for the tensor Tucker rank can be substantially sub-optimal in terms of the number of observations needed for exact recovery and introduce a very simple new convex relaxation that is theoretically and empirically much better. We also propose algorithms to solve these models that are based on ADAL, Frank-Wolfe and prox-gradient methods, and empirically study their performance on both simulated and real data.

2 - Optimal Randomized Gradient Methods

Cong Dang, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32603, United States of America, congdd@ufl.edu, Guanghui Lan

We present optimal primal dual randomized methods which only access part of dataset in each iteration.

3 - Perspectives and Extensions of Renegar's Efficient First-Order Methods for Conic Optimization

Robert Freund, Professor, MIT Sloan School of Mgmt., 77 Massachusetts Ave., Cambridge, MA, 02139, United States of America, rfreund@mit.edu

In 2014 Renegar presented a novel nonlinear transformation of a conic optimization problem into a non-smooth convex optimization problem over a simple set, which is ideally-suited for solution by first-order methods. He further improved the complexity of his method from a quadratic to a logarithmic dependence on the quality of the initial point through a novel "sub-scheme." In this talk we present a new perspective on Renegar's work that places it in the context of projective transformations and projective geometry, and that eliminates the need for any sub-scheme to achieve improved complexity. We also generalize these results to a particular structured class of convex optimization problems.

■ TD05

05- Kings Garden 1

Global Efficiency of Nonconvex Optimization Algorithms

Cluster: Nonlinear Programming

Invited Session

Chair: Coralia Cartis, Associate Professor, University of Oxford, Mathematical Institute, Oxford, United Kingdom, coralia.cartis@maths.ox.ac.uk

1 - A Trust Region Method with Worst-Case Iteration Complexity O(eps^(-3/2)) for Nonconvex Optimization

Frank E. Curtis, Lehigh University, 200 W Packer Ave, Bethlehem, PA, United States of America, frank.e.curtis@gmail.com

We present a trust region method for unconstrained nonconvex optimization that, in the worst-case, is able to drive the norm of the gradient of the objective below a prescribed threshold eps > 0 after at most O(eps^(-3/2)) iterations. Our work is inspired by the recently proposed Adaptive Regularisation framework using Cubics (i.e., the ARC algorithm), which attains the same worst-case complexity bound. Our algorithm is modeled after a traditional trust region algorithm, but employs modified step acceptance criteria and a novel trust region updating mechanism that allows it to achieve this desirable property. Importantly, our method also maintains standard global and fast local convergence guarantees. Numerical results are presented.

2 - Classical Unconstrained Optimization Based on “Occasionally Accurate” Random Models

Katya Scheinberg, Professor, Lehigh University, Department of Industrial Engineering, Bethlehem, PA, United States of America, katyas@lehigh.edu, Coralia Cartis

We will present a very general framework for unconstrained optimization which includes methods using random models for deterministic and stochastic optimization. We make assumptions on the stochasticity that are different from the typical assumptions of stochastic and simulation-based optimization. Several convergence and expected convergence rates results have been developed under this framework for standard optimization methods, such as line search, trust region method, direct search methods and adaptive regularization with cubics. We will present some of these results and outline the general analysis techniques based on theory of stochastic processes.

3 - Evaluation Complexity Bounds for Nonconvex Optimization under Milder Assumptions

Coralia Cartis, Associate Professor, University of Oxford, Mathematical Institute, Oxford, United Kingdom, coralia.cartis@maths.ox.ac.uk, Nick Gould, Philippe Toint

We consider first- and second-order regularisation methods, with varying powers of the regularization, applied to nonconvex unconstrained optimization problems that have Holder-continuous gradient and Hessian, respectively. We analyse the interplay between the exponent of the Holder properties and the power of the regularization term, recovering some known results and discovering some new ones.

■ TD06

06- Kings Garden 2

Optimization in Wireless Communication Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Di YuanVisiting, Professor, University of Maryland, College Park, MD, United States of America, diyuan@umd.edu

1 - Power Efficient Uplink Scheduling in SC-FDMA: Benchmarking by Column Generation

Hongmei Zhao, Linköping University, Mathematics Department, Linköping, Sweden, hongmei.zhao@liu.se, Di Yuan, Lei Lei

We study resource allocation in cellular systems and consider the problem of finding a power efficient scheduling in an uplink single carrier frequency division multiple access system (SC-FDMA). We first provide a basic integer linear programming formulation. Then we propose a much stronger column-oriented formulation and a corresponding column generation method, as well as an enhanced column generation scheme.The computational evaluation demonstrates that compared with a poor performance by the integer linear programming formulation,the column generation approach serves well for the purpose of benchmarking results for large-scale instances.

2 - Integer Programming Formulations for Packet Delay and Energy Minimization in WMSN

Michal Pioro, Professor, Lund University, EIT LTH Box 118, Lund, 221 00, Sweden, michal.pioro@eit.lth.se, Antonio Capone, Yuan Li

Cooperative forwarding of packets and interference cancellation are two recent techniques capable of improving traffic throughput in wireless mesh sensor networks (WMSN). The improvement is achieved thanks to (i) possible broadcasting of the same packet simultaneously from several nodes, and (ii) cancellation of signals carrying packets that are already present at the nodes. We develop integer programming (IP) formulations for packet delay and energy minimization for WMSN, showing how the standard signal to interference and noise ratio constraint used in IP approaches to WMSNs can be adjusted to take the two techniques into account. We also present numerical results illustrating the gain achieved with these two techniques.

■ TD07

07- Kings Garden 3

Advances in Integer Programming III

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Santanu Dey, Associate Professor, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, United States of America, santanu.dey@isye.gatech.edu

1 - Exploiting Submodularity in Nonlinear Integer Programming

Shabbir Ahmed, Professor, Georgia Institute of Technology, 765 Ferst Drive, Room 410 Groseclose Bld., Atlanta, GA, 30332, United States of America, shabbir.ahmed@isye.gatech.edu, Jiajin Yu

A variety of nonlinear integer programs involve nonlinear functions of binary variables exhibiting a diminishing marginals property known as submodularity. This talk will discuss approaches to exploit submodularity to develop effective mixed integer linear programming based methods for such problems.

2 - The Boolean Quadric Polytope for Graphs with Bounded Treewidth

Carla Michini, UW Madison, 330 North Orchard Street, Madison, WI, 53715, United States of America, michini@wisc.edu, James Luedtke

In this work we study the problem of minimizing a quadratic function over binary vectors. The boolean quadric polytope arises from a standard linearization of the objective function and has been extensively studied in the literature. We focus on problems where the quadratic form yields a graph with special structure, and we exploit such structure to find tight relaxations. While in general the boolean quadric polytope is known to admit no compact linear extended formulation, for graphs with bounded treewidth we derive an extended formulation of polynomial size.

3 - An Extended Formulation for K-partitioning

Arnaud Knippel, INSA Rouen, Avenue de l’Université, Saint-Etienne-du-Rouvray, 76801, France, arnaud.knippel@insa-rouen.fr, Zacharie Ales

To partition elements in K parts based on similarity or dissimilaritiy measures, we propose an extended formulation with edge variables, representative variables and artificial variables. It has no symmetry and gives good relaxations compared to some other classical formulations. We give polyedral results and present a numerical study.

■ TD08

08- Kings Garden 4

Optimization of Submodular Functions

Cluster: Combinatorial Optimization

Invited Session

Chair: Jan Vondrak, IBM Almaden Research Center, 650 Harry Rd, San Jose, CA, 95120, United States of America, jvondrak@gmail.com

1 - Constraint Satisfaction Problems and Generalisations of Submodularity

Stanislav Zivn, Associate Professor, Oxford University, Wolfson Building, Parks Road, Oxford, OX1 3QD, United Kingdom, standa.zivny@cs.ox.ac.uk

In this talk, we survey recent results on the computational complexity of optimisation problems that can be cast as Valued Constraint Satisfaction Problems (VCSPs). We will focus on problems that can or provably cannot, assuming standard complexity-theoretic assumptions, be solved optimally in polynomial time. Moreover, we will links these results to generalisations of submodularity.

2 - Fast Submodular Maximization

Roy Schwartz, Postdoctoral Researcher, Princeton University, 35 Olden St., Princeton, NJ, 08540, United States of America, roysch@cs.princeton.edu

Submodular maximization captures both classical problems in combinatorial optimization and recent more practical applications that arise in other disciplines, e.g., machine learning and data mining. Typically, the size of the inputs in these applications is very large. Hence, it is interesting to devise algorithms that in addition to providing a provable guarantee on the quality of the output are also very fast and simple. In this talk I will present several such examples from recent years, including unconstrained submodular maximization and maximization of a submodular function given a cardinality constraint.

3 - Distributed Submodular Maximization via Randomized Composable Core-sets

Vahab Mirrokni, Senior Staff Research Scientist, Google Research, 111 8th Ave, New York, United States of America, mirrokni@gmail.com, Morteza Zadimoghaddam

An effective technique for solving optimization problems over massive data sets is to partition the data into smaller pieces, solve the problem on each piece and compute a representative solution from it, and finally obtain a solution inside the union of the representative solutions. In this paper, we show how to apply this technique for monotone and non-monotone submodular maximization under a cardinality constraint, and prove the first constant-factor distributed approximation algorithms for these problems in two rounds of computation (e.g,. MapReduce). Our results provide a theoretical foundation to empirical effectiveness of similar algorithms.

■ TD09

09- Kings Garden 5

Topics in Robust Optimization I

Cluster: Robust Optimization

Invited Session

Chair: Dick den Hertog, Tilburg University, P.O. Box 90153, Tilburg, Netherlands, D.denHertog@uvt.nl

1 - Linearized Robust Counterparts of Two-Stage Robust Optimization Problem

Amir Ardestanijaafari, HEC Montreal, 3165 Edouard Montpetit Blvd, Apt 36, Montreal, QC, H3T 1K3, Canada, amir.ardestani-jaafari@hec.ca, Erick Delage

We study two-stage robust optimization problem wherein some decisions can be made when the actual data is revealed. Since this problem is computationally intractable we propose a conservative tractable approximation scheme for this problem based on linearizing the cross terms that appears due to the recourse problem. We relate this new scheme to methods that are based on exploiting affine decision rules. Furthermore, we show that our proposed method can be exploited to provide exact solutions in a family of robust multi-item newsvendor problem. Using a robust facility location problem, we also show how our proposed method can be used to derive conservative approximations that are tighter than existing tractable methods.

2 - Worst-Case Expectation Minimization with Given Means and Mean Absolute Deviations

Krzysztof Postek, Tilburg University, P.O. Box 90153, Tilburg, 5000LE, Netherlands, K.Postek@uvt.nl, Dick den Hertog, Bertrand Melenberg, Aharon Ben-Tal

We derive computationally tractable robust counterparts for constraints containing worst-case expected values of functions that are convex in the uncertain parameters. We assume knowledge of the supports, means and mean absolute deviations of the uncertain parameters. We show that the method provides solutions with good average-case performance. Moreover, we show this new method can be used to deal with convex constraints that contain implementation error or constraints that are convex in the linearly adjustable variables.

3 - Robust Solutions for Systems of Uncertain Linear Equations

Jianzhe Zhen, Tilburg University, P.O. Box 90153, Tilburg, 5000 LE, Netherlands, j.zhen@uvt.nl, Dick den Hertog

We propose two new ways for obtaining robust solutions of systems of linear equations that contain uncertain parameters. The first method calculates the center of the maximal inscribed ellipsoid of the set of possible solutions. The second method minimizes the expected violations. We compare these two new methods both theoretically and numerically with an existing method. Applications to the input-output model, Colley's Matrix Rankings and Google's PageRank demonstrate the advantages of the two new methods.

■ TD10

10- Kings Terrace

Quantitive Finance

Cluster: Finance and Economics

Invited Session

Chair: William Ziemba, University of British Columbia, Main Mall, Vancouver, Canada, wtzimi@me.com

1 - Optimal Capital Growth with Controls on the Rate and Size of Shortfalls

Leonard MacLean, Professor, Dalhousie University, 6100 University Avenue, Halifax, Canada, L.C.MacLean@dal.ca, Yonggan Zhao, William Ziemba

We consider the problem of the maximizing the growth rate of capital through investment in risky assets. The risk of capital shortfalls is controlled by: (i) a constraint on the shortfall rate requiring wealth to exceed an ex-ante discrete time wealth path with high probability; and (ii) a penalty on shortfall size in the objective using a convex function of the shortfall. The multi-period stochastic investment model is reformulated as a non-convex deterministic program, and the optimal constrained growth wagers at discrete points in time are calculated.

2 - Behaviouralizing Black-Litterman Part I: Behavioural Biases and Expert Opinions in a Diffusion Setting

Sebastien Lleo, Associate Professor, NEOMA Business Scholl, 59, rue Pierre Taittinger, Reims, 51100, France, seblleo@gmail.com, Mark Davis

This paper proposes a continuous time version of the Black-Litterman model that accounts for, and correct, some of the behavioural biases that analysts may exhibit. Our starting point is the Black-Litterman in Continuous Time model [QFL, 2013], with market data from eleven ETFs . We calibrate analyst views, show how to mitigate the impact of behavioural biases and compare the results of six dynamic investment models. We find that the views have a modest effect on the Kelly portfolio, but a large impact on the intertemporal hedging portfolio. Overall, the role of analyst views in the portfolio section process appears more about providing extra scenarios that are not reflected in historical data, rather than providing accurate forecasts.

3 - Reward-to-Variability Performance Measures

Mikhail Zhitlukhin, Research Fellow, Steklov Mathematical Institute, 8 Gubkina St., Mosow, 119991, Russia, mikhailzh@mi.ras.ru

We will consider minimal monotone functionals that dominate ratios of concave and convex functionals in a context of evaluation of performance of investments in financial markets. They have a natural interpretation in terms of the trade-off between profit and risk and generalize the Sharpe ratio (expected excess return divided by its standard deviation). The main result provides a dual representation of such functionals which allows to evaluate them in an efficient way.

■ TD11

11- Brigade

TSP and Relatives

Cluster: Combinatorial Optimization

Invited Session

Chair: Diego Pecin, Postdoctoral Researcher, Polytechnique Montreal, Université de Montréal - GERAD, Montreal, Canada, diegopecin@gmail.com

1 - 2-parity Inequalities for the Traveling Salesman Problem: Separation and Computational Experiments

Daniel Espinoza, Associate Professor, Universidad de Chile, Department of Industrial Engineering, Av. Republica 701, Santiago, RM, 837-0439, Chile, daespino@gmail.com, William Cook, Marcos Goycoolea

In this work we present a new separation algorithm for separating so-called 2-parity and domino parity inequalities for the TSP when the support graph is planar. The algorithm introduces new dominance rules for dominoes that greatly reduce the practical running time. We will present computational results on TSPLIB and other instances, including the 100,000 city problem known as Mona Lisa TSP.

2 - Variants of TSP Art

Robert Bosch, Professor, Oberlin College, Department of Mathematics, King 205 A, Oberlin, OH, 44074, United States of America, rbosch@oberlin.edu, Tom Wexler

TSP Art is produced by (1) applying a stippling algorithm to a grayscale image, (2) considering the resulting collection of dots to be the cities of a Euclidean TSP instance, (3) finding a high-quality tour of the cities, and finally, (4) drawing the tour. One well known example is the Mona Lisa TSP Challenge. Here we present several variants of TSP Art. In the process, we examine the roles played by the stippling and tour-finding algorithms.

3 - A New Branch-Cut-and-Price Algorithm for the Vehicle Routing Problem with Time Windows

Diego Pecin, Postdoctoral Researcher, Polytechnique Montreal, Université de Montréal - GERAD, Montreal, Canada, diegopecin@gmail.com, Claudio Contardo, Guy Desaulniers, Eduardo Uchoa

This talk introduces a new Branch-Cut-and-Price algorithm for the VRPTW that combines recent techniques for VRPs, such as: ng-routes, bidirectional pricing, strong branching, variable fixing, route enumeration, robust cuts, limited-memory Subset Row Cuts (lm-SRCs) —- a relaxation of the SRCs that is more friendly with the labeling algorithms used to solve the pricing. Our results show that all the 100-customer Solomon and several 200-customer Homberger instances can now be solved to optimality.

■ TD12

12- Black Diamond

Rail and Maritime Applications

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Mario Ruthmair, AIT Austrian Institute of Technology, Donau-City-Strasse 1, Vienna, 1220, Austria, mario.ruthmair@ait.ac.at

1 - Freight Train Routing in Congested Railway Networks

Torsten Klug, TU Berlin, Strafle des 17. Juni 135, Berlin, 10623, Germany, klug@zib.de, Thomas Schlechte, Ralf Borndörfer, Armin Fügenschuh

We investigate the strategic routing of freight trains in congested railway networks with mixed traffic. The problem has a strategic character since it asks only for a coarse routing through a marcroscopic network without the precise timings. We formulate the problem as mixed-integer non-linear program (MINLP) and adapt the congestion concept from road traffic to rail traffic. We linearize the non-linear terms of the objective and solve the resulting linear mixed-integer program with the commercial state of the art MIP solver CPLEX via a sequential approach. In this talk we propose the sequential MIP approach and present some results solving demand situations for the whole German railway network.

2 - Mixed Integer Linear Programming Models for the Interdependent Lock Scheduling Problem

Mario Ruthmair, AIT Austrian Institute of Technology, Donau-City-Strasse 1, Vienna, 1220, Austria, mario.ruthmair@ait.ac.at, Matthias Prandtstetter, Ulrike Ritzinger

We consider the Interdependent Lock Scheduling Problem which arises in ship traffic on rivers with multiple watergates. Each ship starts at a fixed time and follows a given path (upstream or downstream) along which it has to pass a series of watergates. The aim of the problem is to find a lock schedule resulting in minimal total ship travel times. In a weighted objective we also consider the minimization of the number of lockages. We present several mixed integer linear programming models and use CPLEX to solve them.

3 - Computing Equilibrium in the Stable Dynamic Transportation Model

Yuriy Dorn, PreMoLab MIPT, Institutsky per 1, Dolgoprudny, Russia, dornyv@yandex.ru, Alexander Gasnikov, Yurii Nesterov

Computing equilibrium in the Stable Dynamic transportation model (Nesterov and de Palma, 2003) can be reduced to huge-scale non-smooth convex optimization problem with constraints. We propose two new representations for this model: linear programming problem and non-smooth convex optimization problem without constraints. For the second representation we propose new method, which use structure of the problem. We also provide complexity analysis to this method and compare him with other methods for huge-scale optimization problems.

■ TD13

13- Rivers

Foundational Issues Motivated by Simplex Method and Pivoting Algorithms

Cluster: Conic Programming

Invited Session

Chair: Chris Ryan, University of Chicago, Chicago, IL United States of America, chris.ryan@chicagobooth.edu

1 - A Projection Based Relaxed Semismooth-Newton-Method for Conic Optimization-Problems

Felix Lieder, Heinrich-Heine-Universitaet Düsseldorf, Universitaetsstr. 1, Düsseldorf, Germany, Felix.lieder@hhu.de

In this talk we present a new projection based approach for solving conic optimization problems. In contrast to most other authors, we work with indefinite subroblems coming from our nonconvex formulation. These subproblems depend one or more relaxation parameters. In its most relaxed form, our method reduces to a simple fixpoint iteration, which has global convergence properties. Assuming that one is able to efficiently project on the involved cones, large problems can be handled. To obtain faster local convergence rates, we adjust our relaxation parameter(s) and use second order information. We present promising numerical results on semidefinite programs arising from relaxations of combinatorial problems.

2 - Strong Symmetric Duality and Simplex Type Algorithm for Continuous Linear Programs

Evgeny Shindin, PhD Student, The University of Haifa, Department of Statistics, Haifa, 31905, Israel, shindin@netvision.net.il, Gideon Weiss

We consider continuous linear programs over a continuous finite time horizon T, with a constant coefficient matrix, linear right hand side functions and linear cost functions, we search for optimal solutions in the space of functions of bounded variation. This generalizes separated continuous linear programms as formulated by Anderson, Pullan, and Weiss. We formulate a symmetric dual, show strong duality, give a detailed description of optimal solutions, and define a combinatorial analogue to basic solutions of standard LP. We present an algorithm that solves these problems in a finite bounded number of steps, using an analogue of the simplex method, in the space of measures.

3 - Projection: A Unified Approach to Semi-Infinite Linear Programs and Duality in Convex Programming

Chris Ryan, University of Chicago, Chicago, IL, United States of America, chris.ryan@chicagobooth.edu, Kipp Martin, Amitabh Basu

Fourier-Motzkin (FM) elimination is a projection algorithm for solving LPs. We extend FM elimination to semi-infinite LPs (SILPs) with finitely many variables and infinitely many constraints. Applying projection leads to new characterizations of properties for primal-dual pairs of SILPs. Our procedure yields a classification of variables — clean vs. dirty — to determine the existence of duality gaps. Our approach has applications in finite-dimensional convex optimization. For example, sufficient conditions for a zero duality gap, such as the Slater constraint qualification, are reduced to guaranteeing that there are no dirty variables. This leads to completely new proofs of sufficient conditions for zero duality gap.

■ TD14

14- Traders

Utility Tradeoffs in Mechanism Design

Cluster: Game Theory

Invited Session

Chair: Nima Haghpanah, MIT, 32 Vassar Street, Cambridge, MA, United States of America, nima.haghpanah@gmail.com

1 - Optimal Prior-Free Benchmarks

Sam Taggart, Northwestern University, 2145 Sheridan Rd, Evanston, IL, United States of America, samuelptaggart@gmail.com, Jason Hartline

For many optimization problems with limited information there is no pointwise optimal algorithm. Worst-case (a.k.a. prior-free) analysis can proceed by comparing the performance of the algorithm to a performance benchmark. One compelling standard for benchmark selection is Bayesian justification: any algorithm that approximates the benchmark should also be approximately optimal when there is a prior distribution over inputs. This work considers optimization over such benchmarks - i.e., finding the Bayesian justified benchmark that admits the tightest approximations. We exhibit the approach in designing a mechanism for selling a single item to optimize the cumulative utility of bidders.

2 - Mechanisms for Fair Attribution

Eric Balkanski, Harvard University, Maxwell Dworkin 219, 33 Oxford Street, Cambridge, MA, United States of America, ericbalkanski@g.harvard.edu, Yaron Singer

We consider a new genre of mechanism design, which to the best of our knowledge, has not been explored before. In particular we consider mechanisms for procurement which attribute the buyer's budget in a fair manner. We establish natural notions of fairness that are based on concepts from cooperative game theory. Our main result shows that for any monotone submodular function there exists a fair mechanism which is a 3-approximation and that this is tight. We discuss several special cases for which this approximation ratio can be improved and several natural extensions.

3 - Optimal Revenue-Utility Tradeoffs: Applications to Dynamic and Competing Mechanisms

Nima Haghpanah, MIT, 32 Vassar Street, Cambridge, MA, United States of America, nima.haghpanah@gmail.com, Itai Ashlagi, Constantinos Daskalakis

We propose the study of a single-dimensional mechanism design problem, termed optimal revenue-utility tradeoff, in which the objective is to maximize a linear combination of the seller's revenue and a function of the bidder's utility. Under general conditions, we provide simple mechanisms that solve or approximately solve this problem, and study three applications of our proposed problem and solution. First, we show how it can be directly used to solve instances of optimal taxation. Second, we use it to provide optimal dynamic mechanisms for selling two items to one buyer subject to strongly ex-post individual rationality conditions. Third, our problem captures single-dimensional revenue maximization in the presence of competing mechanisms.

■ TD15

15- Chartiers

Mixed-Integer Optimal Control for PDEs

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Falk Hante, Dr., University of Erlangen-Nuremberg, Cauerstr. 11, Erlangen, 91058, Germany, falk.hante@fau.de

1 - Relaxation Methods for PDE Mixed-Integer Optimal Control

Falk Hante, Dr., University of Erlangen-Nuremberg, Cauerstr. 11, Erlangen, 91058, Germany, falk.hante@fau.de

The talk provides an introduction to the problem class including some benchmark problems from gas network operation, thermal manufacturing and traffic flow control. One way to assess the problem class is based on relaxation of the integer constraints. For this method, a-priori estimates for semilinear evolutions on Banach spaces are presented which allow an explicit construction of integer-controls from a relaxed control up to arbitrary precision. The method is demonstrated on numerical examples.

2 - Questions of Algorithm and Software Design for Optimal Control in Gas Networks

Marc C. Steinbach, Leibniz Universitaet Hannover, Welfengarten 1, Hannover, 30167, Germany, mcs@ifam.uni-hannover.de

Transient optimization in gas networks poses major mathematical challenges by combining nonsmooth discrete-continuous optimization with ill-conditioned PDE constraints and complicated technical devices on large graphs. Based on earlier experience with small gas network models, the talk presents structural considerations for addressing some of these challenges in a potential solution framework. We also discuss fundamental design issues arising in the development of numerical software for the above problem and other highly complex applications.

3 - A Convex Analysis Approach for Computing Switching Controls for PDEs

Armin Rund, Karl-Franzens-University Graz, Heinrichstrasse 36, Graz, 8010, Austria, armin.rund@uni-graz.at, Karl Kunisch, Christian Clason

This talk is concerned with optimal control problems for parabolic partial differential equations subject to a switching penalty. Replacing this penalty with its convex relaxation leads to a primal-dual optimality system that allows an explicit pointwise characterization and whose Moreau-Yosida regularization is amenable to a semismooth Newton method in function space. Numerical results are presented and the extension to optimal switching between an arbitrary number of controls is discussed.

■ TD16

16- Sterlings 1

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Rosiane de Freitas, Professor/Sys Comp. Eng. PhD, IComp/UFAM, Av. Rodrigo Octàvio, 3000, Aleixo, Campu, Manaus, AM, Brazil, rosiane@icomp.ufam.edu.br

1 - A MILP Model for Order-Based Continuous Casting Planning at SSAB

Nils-Hassan Quttineh, Senior Lecturer, Linköping University, Linköping University, Department of Mathematics, Linköping, 58183, Sweden, nils-hassan.quttineh@liu.se

We present the challenges of planning the order-driven continuous casting production at the Swedish steel producer SSAB. Customers place orders for end products, which is translated into a demand of slabs of a certain steel grade and with given order-specific restrictions on weight, length and breadth. The overall planning problem is to minimize production waste while fulfilling the order-based demand, and we decomposed the problem by firstly schedule and group orders by steel grade, and secondly decide in which sequence the scheduled orders for each day should be cast. A MILP model is available which produces efficient production plans and simultaneously facilitates the daily work situation for the planners at SSAB.

2 - An Extended Formulation for Minsum Scheduling Problems on Unrelated Parallel Machines

Kerem Bulbul, Assoc. Prof., Sabanci University, Sabanci University, Orhanli, Tuzla, Istanbul, 34956, Turkey, bulbul@sabanciuniv.edu, Halil Sen

We present a novel extended mixed integer linear programming formulation – attacked by Benders decomposition with strengthened cuts – for solving minsum scheduling problems on unrelated parallel machines. Our formulation yields tight lower bounds and allows for the construction of near-optimal feasible solutions for instances with up to 5 machines and 200 jobs under the total weighted tardiness and total weighted earliness/tardiness objectives. Furthermore, the formulation turns out to be exact for the total weighted completion time objective, and instances with up to 1000 jobs and 8 machines are solved to optimality within a few seconds.

3 - MIP Formulations for Parallel Machine Scheduling Problems Based on Due Date Penalties

Rosiane de Freitas, Professor/Sys Comp. Eng. PhD, IComp/UFAM, Av. Rodrigo Octavio, 3000, Aleixo, Campu, Manaus, AM, Brazil, rosiane@icomp.ufam.edu.br, Bruno Dias, Rainer Amorim

This work addresses mixed integer programming formulations for parallel scheduling problems, with independent and non-preemptive jobs containing arbitrary processing times, to regular and non-regular objective functions based on due dates penalties, as lateness, unity penalty, tardiness and earliness-tardiness objective functions. A comparative analysis is presented, considering both theoretical aspects as well as more appropriate algorithmic strategies, where a battery of tests is performed with instances of literature.

■ TD17

17- Sterlings 2

Constraint Qualification and Convergence of Algorithms

Cluster: Nonlinear Programming

Invited Session

Chair: Roberto Andreani, Dr, State University Campinas- Brazil, Rua Sergio Buarque de Holanda, 651, Campinas, 13083-859, Brazil, andreani@ime.unicamp.br

1 - A Cone-Continuity Constraint Qualification and Algorithmic Consequences

Roberto Andreani, Dr, State University Campinas- Brazil, Rua Sérgio Buarque de Holanda, 651, Campinas, 13083-859, Brazil, andreani@ime.unicamp.br, Paulo J. S. Silva, Alberto Ramos, Josè Mario Martìnez

Every local minimizer of a smooth constrained optimization problem satisfies the sequential Ap- proximate Karush-Kuhn-Tucker (AKKT) condition. This optimality condition is used to define stop- ping criteria of many practical nonlinear programming algorithms. It is natural to ask for conditions on the constraints under which AKKT implies KKT. These conditions will be called Strict Constraint Qualifications (SCQ). In this paper we define a Cone-Continuity Property (CCP) that will be showed to be the weakest possible SCQ. Its relation with other constraint qualifications will also be clarified. In particular, it will be proved that CCP is strictly weaker than the Constant Positive Generator (CPG) constraint qualification.

2 - On Second Order Optimality Conditions for Nonlinear Optimization

Gabriel Haeser, Dr, University of São Paulo, Rua do Matao, 1010, São Paulo, Brazil, ghaeser@gmail.com, Paulo J. S. Silva, Roger Behling, Roberto Andreani

In this work we present new weak conditions that ensure the validity of necessary second order optimality conditions (SOC) for nonlinear optimization. We are able to prove that weak and strong SOCs hold for all Lagrange multipliers using Abadie-type assumptions. We also prove weak and strong SOCs for at least one Lagrange multiplier imposing the Mangasarian-Fromovitz constraint qualification and a weak constant rank assumption.

3 - On Second-Order Sequential Optimality Conditions for Nonlinear Optimization and Applications

Alberto Ramos, PhD Student, University of São Paulo, Rua do Matão, 1010, São Paulo, SP, 13278-138, Brazil, aramos27@gmail.com, Gabriel Haeser, Paulo J. S. Silva, Roberto Andreani

Sequential optimality conditions provide adequate theoretical tools to justify stopping criteria formany nonlinear programming solvers. Most of them use only first-order information. In this paper. we introduce new sequential optimality conditions that take into account first and second-order information. We prove that well established algorithms with convergence to second-order stationary points produce sequences whose limit points satisfy these new condition. In particular, we show global convergence of augmented Lagrangian and Regularized SQP to second-order stationary points under a weak constraint qualification.

■ TD18

18- Sterlings 3

Convex Conic Optimization: Models, Properties, and Algorithms I

Cluster: Conic Programming

Invited Session

Chair: Farid Alizadeh, Professor, Rutgers University, MSIS department, 100 Rockefallar, room 5142, Piscataway, NJ, 08854, United States of America, alizadeh@rci.rutgers.edu

1 - Cone-Free Infeasible-Start Primal-Dual Methods

Mehdi Karimi, PhD Student, Department of Combinatorics and Optimization, University of Waterloo, 200 University Avenue West,, Waterloo, ON, N2L 3G1, Canada, m7karimi@uwaterloo.ca, Levent Tuncel

We develop an infeasible-start primal-dual algorithm for convex optimization problems equipped with a self-concordant barrier for the convex domain of interest and its easy-to-calculate Legendre-Fenchel conjugate. Our approach is cone-free in the sense that we directly apply our techniques to the given good formulation without reformulating it in a conic form. After defining our central path, we present a long-step path following algorithm and prove that it solves the problem in polynomial time; returns an optimal solution if it exists, otherwise detects infeasibility or unboundedness. We introduce our Matlab-based code that solves a large class of problems including LP, SOCP, SDP, QCQP, Geometric programming, and Entropy programming.

2 - Pseudomonotonicity and Related Properties in Euclidean Jordan Algebras

Jiyuan Tao, Professor, Loyola University Maryland, 4501 North Charles Street, Baltimore, MD, 21210, United States of America, JTao@loyola.edu

In this talk, we introduce the concept of pseudomonotonicity on symmetric cones and present interconnections between pseudomonotonicity, monotonicity, the Z-property, the P_0-property, the column sufficiency property, the P-property, and the globally uniquely solvable property in the setting of Euclidean Jordan algebras.

3 - Optimization with Multivariate Risk Constraints Based on a General Class of Scalarization Functions

Gabor Rudolf, Koc University, Rumeli Feneri Yolu, Sariyer, Istanbul, 34450, Turkey, grudolf79@gmail.com, Nilay Noyan

We consider decision making problems where the decision results in multiple uncertain outcomes represented by a vector-valued random variable, and decision makers' preferences are incorporated via coherent risk measures. In a multivariate context scalarization functions are often used to combine the multiple outcomes. While the current literature on stochastic multi-criteria optimization relies almost exclusively on linear scalarization functions, a variety of other functions (such as Chebysev scalarizations) are commonly used in the deterministic multi-objective literature. In this work we aim to incorporate a general class of scalarization functions into risk-constrained stochastic multivariate decision problems.

■ TD19

19- Ft. Pitt

Hybrid Optimization III

Cluster: Constraint Programming

Invited Session

Chair: Willem-Jan van Hoeve, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, United States of America, vanhoeve@andrew.cmu.edu

1 - Practical Solution of Rich Routing Problems with CP and Metaheuristics

Luca Di Gaspero, Dr., University of Udine, DIEGM, via delle Scienze 208, Udine, UD, I-33100, Italy, luca.digaspero@uniud.it

A promising research line in the optimization community regards the hybridization of exact and heuristics methods. Among other alternatives we consider the specific integration of two complementary optimization paradigms, namely Constraint Programming (CP), for the exact part, and metaheuristics. We present the integration of Large Neighborhood Search and Ant Colony Optimization methods within the Gecode CP system and we show how it can be used to solve two practical optimization problems in the Vehicle Routing domain: the Balancing Bike-Sharing System problem, which aims at increasing the efficiency of public bike-sharing systems, and the HomeCare scheduling problem, which concerns the efficient planning of caregivers for home assistance.

2 - Accelerating the Development of Efficient CP Optimizer Models

Philippe Laborie, IBM, 9, rue de Verdun, Gentilly, 94253, France, phi.laborie@free.fr

The IBM Constraint Programming optimization system CP Optimizer was designed to provide automatic search and a simple modeling of discrete optimization problems, with a particular focus on scheduling applications. It is used in industry for solving operational planning and scheduling problems. We will give an overview of CP Optimizer and then describe in further detail a set of features such as input/output file format, warm-start or conflict refinement that help accelerate the development of efficient models.

■ TD20

20- Smithfield

Accelerated and Optimal First Order Methods

Cluster: Nonsmooth Optimization

Invited Session

Chair: Clovis Gonzaga, Professor, Federal University of Santa Catarina, R. Jorge Cherem, 57, Florianopolis, SC, 88053-620, Brazil, ccgonzaga1@gmail.com

1 - Accelerated Steepest Descent Algorithms for Convex Quadratic Functions

Clovis Gonzaga, Professor, Federal University of Santa Catarina, R. Jorge Cherem, 57, Florianopolis, SC, 88053-620, Brazil, ccgonzaga1@gmail.com, Ruana Schneider

The steepest descent algorithm with exact line searches (Cauchy algorithm) is inefficient, generating oscillating step lengths and a sequence of points converging to the span of the eigenvectors associated with the extreme eigenvalues. The performance becomes very good if a short step is taken at every (say) 10 iterations. We show a new method for estimating short steps, and also how to add a short step at each iteration with low computational cost. Finally, we use the roots of a certain Chebyshev polynomial to further accelerate the method.

2 - Optimized Gradient Methods for Smooth Convex Minimization

Donghwan Kim, Postdoctoral Research Fellow, University of Michigan, 1301 Beal Avenue, Ann Arbor, MI, 48109, United States of America, kimdongh@umich.edu, Jeffrey A. Fessler

We introduce new optimized first-order algorithms for smooth unconstrained convex minimization. Drori and Teboulle recently described a numerical method for computing the N-iteration optimal step coefficients in a class of first-order algorithms. However, the numerical method and the corresponding first-order algorithm are computationally expensive. By extending Drori and Teboulle's numerical analysis, we propose optimized gradient methods (OGM) that achieve a convergence bound that is two times faster than Nesterov's fast gradient methods (FGM); our bound is found analytically and refines the numerical bound. Furthermore, we show that the proposed OGM methods have efficient recursive forms that are remarkably similar to Nesterov's FGM.

3 - A General Framework for Accelerating First-Order Algorithms for Smooth Convex Optimization

Haihao Lu, MIT, Mathematics Department, 77 Massachusetts Ave., Cambridge, MA, 02139, United States of America, haihao@mit.edu

We present a general framework for constructing accelerated gradient methods for the class of smooth convex optimization problems. This unifying framework provides novel interpretations of the accelerating nature of the methods, and enables the development of a new family of accelerated methods. The framework can be applied to Nesterov's classical accelerated method, the dual-averaging method, and Tseng's accelerated proximal methods.

■ TD21

21-Birmingham

Computation and Applications of Conic Optimization

Cluster: Conic Programming

Invited Session

Chair: Hayato Waki, Institute of Mathematics for Industry, Kyushu University, Motooka 744,, NIshi-ku,, Fukuoka, 819-0395, Japan, waki@imi.kyushu-u.ac.jp

1 - Application of Facial Reduction to H-infinity State Feedback Control Problem

Hayato Waki, Institute of Mathematics for Industry, Kyushu University, Motooka 744,, NIshi-ku,, Fukuoka, 819-0395, Japan, waki@imi.kyushu-u.ac.jp, Noboru Sebe

When one encounters numerical difficulties in solving an SDP relaxation problem, one of the reasons may be no interior feasible solutions in the SDP relaxation problem. Facial reduction proposed by Borwein and Wolkowicz is useful for such SDP problems from viewpoint of computation. In this talk, we deal with H-infinity state feedback control problem and provide necessary and sufficient condition for SDP relaxation problems to have interior feasible solutions in terms of the control. Furthermore, we propose a way to remove the numerical difficulty which is available to control systems. Numerical results show that the numerical stability is improved by applying the way.

2 - Facial Reduction for Euclidean Distance Matrix Problems

Nathan Krislock, Assistant Professor, Northern Illinois University, 1425 W. Lincoln Hwy., DeKalb, IL, 60115, United States of America, krislock@math.niu.edu, Yuen-Lam Voronin, Henry Wolkowicz, Dmitriy Drusvyatskiy

A powerful approach to solving problems involving Euclidean distance matrices (EDMs) is to represent the EDM using a semidefinite matrix. Due to the nature of these problems, the resulting semidefinite programming problem is typically not strictly feasible. In this talk we discuss how to take advantage of this lack of strict feasibility by using facial reduction to obtain smaller equivalent problems. This approach has proven very successful for solving large-scale Euclidean distance matrix problems having little to no noise in the given incomplete distance measurements. We will present recent results on the use of facial reduction for solving noisy Euclidean distance matrix problems.

3 - Finding Sparse, Equivalent Sdps using Linear Programming and Combinatorial Techniques

Frank Permenter, Graduate Student, Massachusetts Institute of Technology, 77 Massachusetts Ave, 32-380, Cambridge, MA, 02139, United States of America, fperment@mit.edu, Pablo Parrilo

We present a new method for simplifying SDPs that blends aspects of symmetry reduction with sparsity exploitation. By identifying a subspace of sparse matrices that provably intersects (but doesn't necessarily contain) the set of optimal solutions, we both block-diagonalize semidefinite constraints and enhance problem sparsity for many SDPs arising in sums-of-squares optimization. The identified subspace is in analogy with the fixed-point subspace that appears in symmetry reduction, and, as we illustrate, can be found using efficient combinatorial and linear-programming-based techniques. Effectiveness of the method is illustrated on several examples.

■ TD22

22- Heinz

Variational Analysis in Nonsmooth Optimization I

Cluster: Variational Analysis

Invited Session

Chair: Martin Knossalla, University of Erlangen-Nuremberg, Cauerstr. 11, Erlangen, 91058, Germany, martin.knossalla@fau.de

1 - Bundle Methods with Linear Programming

Shuai Liu, RMIT University, Mathematical and Geospatial Sciences, Melbourne, 3000, Australia, liushuai04235@gmail.com, Andrew Eberhard, Yousong Luo

Traditional bundle methods solve a quadratic programming (QP) subproblem in each iteration. In this presentation, we exploit the feasibility of developing a bundle algorithm that only solves linear subproblems. We minimize the cutting-plane model over a trust region with infinity norm. Starting from convex optimization, we show that the method can be generalized to solve nonconvex problems through convexification. We consider functions that are locally Lipschitz continuous and prox-regular on a bounded level set. Under some conditions and assumptions, we study the convergence of the proposed algorithm through the outer semicontinuity of the proximal mapping.

2 - New Results on Subgradient Methods for Weakly Smooth and Strongly Convex Problems

Masaru Ito, Doctoral Student, Tokyo Institute of Technology, 2-12-1-W8-41, Oh-okayama, Meguro-ku, Tokyo, 152-8552, Japan, ito1@is.titech.ac.jp

We consider subgradient- and gradient-based methods for minimizing weakly smooth and strongly convex functions under a generalized notion of the standard Euclidean strong convexity. We propose a unifying framework for subgradient methods which yields two kinds of particularizations, namely, the Proximal Gradient Method (PGM) and the Conditional Gradient Method (CGM), unifying several existing methods. The unifying framework is developed for convex problems equipped with an oracle inexactness, which includes weakly smooth and strongly convex problems. We use the unifying framework to show optimal convergence of the PGMs for weakly smooth and strongly convex problems, and (nearly) optimal convergence of the CGMs for weakly smooth problems.

3 - Nonsmooth Optimization with Semi-Algebraic Data: Convergence Beyond the Proximal Setting

Edouard Pauwels, Postdoctoral Fellow, Technion, Factulty of Industrial, Engineering and Management, Haifa, 32000, Israel, epauwels@tx.technion.ac.il, JèrÙme Bolte

We focus on convergence of iterative schemes for non-smooth non-convex optimization in finite dimension. Most of current results are given for "prox-friendly" data: the nonsmooth part can be handled through efficiently computable operators. Many methods and applications do not fit this setting. We focus on Sequential Quadratic Programming ideas for general Nonlinear Programs. Despite their large usage, these methods lack satisfactory convergence analysis. This work constitutes a step toward the obtention of such theoretical guaranties. We combine properties of local tangent majorizing models with results from algebraic geometry to analyse the asymptotic properties of two recent methods for solving general Nonlinear Programming problems.

■ TD23

23- Allegheny

Sparse and Low-Rank Optimization in Imaging

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Justin Romberg, Georgia Tech, 777 Atlantic Dr. NW, Atlanta, GA, 30332, United States of America, jrom@ece.gatech.edu

1 - A Moment Approach for Tensor Decomposition

Gongguo Tang, Colorado School of Mines, CO, United States of America, gtang@mines.edu, Parikshit Shah

We develop a new approach for tensor decomposition that comes with theoretical and algorithmic guarantees. Tensor decomposition is formulated as estimating an atomic measure from its moments. By constructing a dual polynomial, we demonstrate that the measure optimization returns the correct decomposition under an incoherent condition on the rank-one factors. We present a hierarchy of semidefinite programs to approximate the measure optimization. By showing that the constructed dual polynomial is a sum-of-squares modulo the sphere, we show that the smallest SDP in the relaxation hierarchy is exact and the decomposition can be extracted from the semidefinite program solutions.

2 - Image Segmentation via Convex Cardinal Shape Composition

Alireza Aghasi, Georgia Institute of Technology, 75 5th St. NW, Atlanta, GA, 30308, United States of America, aghasi@gatech.edu, Justin Romberg

We propose a new shape-based modeling technique for applications in imaging problems. Given a collection of shape priors (a shape dictionary), we define our problem as choosing the right dictionary elements and geometrically composing them through basic set operations to characterize desired regions in an image. This is a combinatorial problem with a large number of possibilities. We propose a convex relaxation to the problem to make it computationally tractable. We take some major steps towards the analysis of the problem and characterizing its minimizers. Applications vary from shape-based characterization, optical character recognition, and shape recovery in occlusion, to other disciplines such as the geometric packing problem.

3 - Non-Convex Regularizers for Non-Gaussian Image Denoising

Albert Oh, University of Wisconsin-Madison, 1415 Engineering Drive, Dept. of Electrical and Computer Eng., Madison, WI, 53706, United States of America, akoh2@wisc.edu, Rebecca Willett

In this talk, we describe several classes of image denoising problems where the noise is non-Gaussian and where non-convex, sparsity-promoting regularization functions (which would be undesirable in Gaussian noise settings) not only admit efficient convex optimization algorithms, but also yield substantial empirical performance gains. The shape of the log-likelihood function helps determine viable and effective classes of regularizers.

■ TD24

24- Benedum

MINLP in Gas Transportation

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Ruediger Schultz, University of Duisburg-Essen, Thea-Leymann-Strasse 9, Essen, Germany, ruediger.schultz@uni-due.de

1 - Checking Feasibility in Stationary Models of Gas Transportation Networks-Structural Characteristics

Claudia Stangl, Dr., University of Duisburg-Essen, Faculty of Mathematics, Thea-Leymann-Str. 9, Essen, 45127, Germany, claudia.stangl@uni-due.de

Checking the feasibility of transportation requests belongs to the key tasks in gas pipeline operation. In its most basic form, the problem is to decide whether a certain quantity of gas can be sent through the network from prescribed entries to prescribed exit points. In the stationary case, the physics of gas flow together with technological and commercial side conditions lead to a pretty big (nonlinear, mixed-integer, finite dimensional) inequality system. The approach presented in this talk relies on transforming nonlinearities into a more accessible form, reducing the problem dimension of the underlying nlp.

2 - Checking Feasibility in Stationary Models of Gas Transportation Networks – Solving the MINLP

Ralf Gollmer, Dr., University of Duisburg-Essen, Faculty of Mathematics, Thea-Leymann-Str. 9, Essen, 45127, Germany, ralf.gollmer@uni-due.de, Ruediger Schultz, Claudia Stangl

The nomination validation for gas networks amounts to feasibility checking for a large mixed-integer non-convex problem. In this talk we present the problem-specific heuristics for choosing most of the binary variables a priori by heuristics, the remaining ones are modeled via the max- and abs-functions. A non-convex nonsmooth nlp results for which properties and reformulation are presented in the talk by Claudia Stangl. Though using heuristics, the approach works quite well for a real-world gas network.

3 - An Approach to Feasibility of Entry and Exit Flows in Gas Networks Using Groebner Bases Methods

Sabrina Nitsche, M.Sc., University of Duisburg-Essen, Faculty of Mathematics, Thea-Leymann-Str. 9, Essen, 45127, Germany, sabrina.nitsche@uni-due.de, Ruediger Schultz

In gas networks, feasibility of balanced entry and exit flows has to be checked very often as the loads at the entry and exit nodes vary. Our objective is to obtain an algebraic solution that is computed only once for a given network and then used to obtain any particular solution. In the talk some numerical results will be presented.

■ TD25

25- Board Room

Energy System Planning

Cluster: Optimization in Energy Systems

Invited Session

Chair: Eddie Anderson, Professor and Associate Dean (Research), University of Sydney, University of Sydney Business School, Sydney, NS, W 2006, Australia, edward.anderson@sydney.edu.au

1 - Expansion Planning in Colombia using Mixed-Integer Programming MILP Approach

Juan Sebastian Londoño Martìnez, Universidad de Antioquia, calle 67 No. 53 - 108, Medellìn, Colombia, juans.londono@udea.edu.co, Oscar Carreño, Richar Alexi Otalvaro Lopez

The expansion transmission planning, is a complex and huge problem. It is due to the different aspects that need to be dealt with for the solution. In Colombia this problem have different approach: XM (Colombian ISO), Transmission firm and UPME (The organization in charge of energy planning in Colombia. In this paper we compare those approach with the state-of-the-art and another worldwide firm. We propose a mathematical model based on MILP whose objective is enhance some critical aspects. This model have been implemented on GAMS and it was tested with the last expansion planning released by UPME.

2 - Construction Planning of a North Sea Offshore Energy Grid

Philipp Hahn, University of Kassel, Heinrich-Plett-Str. 40, Kassel, 34132, Germany, hahn@mathematik.uni-kassel.de, Frank Fischer, Andreas Bley

We consider the problem of extending offshore windparks and connecting them to the shore. The goal is to find a long term (time horizon till 2050) construction plan for building up an energy grid within the northsea that satisfies certain demands of produced power under budget constraints. The power grid is to be build with operable intermediate stages and should also enable the neigbouhring countries to trade energy more flexibly via this network. We present a first model for this problem and some preliminary computational results.

3 - Parallel Computing of Stochastic Programs with Application to Energy System Capacity Expansion

Andrew Liu, Assistant Professor, Purdue University, 315 N Grant St., West Lafayette, IN, 47906, United States of America, andrewliu@purdue.edu, Run Chen

Power grids' planning and operations exhibit extreme multiscale in the time dimension, ranging from hourly unit commitment\dispatch to decades of investment decisions. The linkage between decisions of different time scales usually is simple. Once the linkage is relaxed, the problem can be separated into multiple problems with each representing a single time scale. This presents a natural idea of using an augmented Lagrangian multiplier (ALM) method to design parallel algorithms, which can be embedded into the well-known progressive hedging (PH) algorithm, which itself is amenable for parallel computing. We will show convergence of the embedded algorithm for convex problems and present preliminary numerical results.

■ TD26

26- Forbes Room

Randomized Methods for Minimizing Finite Sums

Cluster: Stochastic Optimization

Invited Session

Chair: Alekh Agarwal, Microsoft Research, 641 Avenue of the Americas, New York, NY, 10011, United States of America, alekha@microsoft.com

1 - Advances in the Minimization of Finite Sums

Mark Schmidt, University of British Columbia, 201 2366 Main Mall, Vancouver, Canada, schmidtmarkw@gmail.com

We consider the problem of minimizing the sum of a finite set of smooth functions. Recently, several authors have proposed algorithms that achieve a linear convergence rate for this problem yet only examine a single randomly-chosen function on each iteration. We examine three recent advances in this vein. First, we show that an improved convergence rate can be achieved through the use of non-uniform selection of the function to update. Second, we show that far fewer gradient evaluations are required to obtain the convergence rate of current memory-free variants of these algorithms. Third, we discuss different strategies for accelerating the methods in order to improve the dependence on the condition number of the problem.

2 - A Lower Bound for the Optimization of Finite Sums

Leon Bottou, Research Scientist, T.B.D., T.B.D., New York, NY, 10003, United States of America, leon@bottou.org, Alekh Agarwal

This paper presents a lower bound for optimizing a finite sum of n functions, where each function is L-smooth and the sum is μ-strongly convex. We show that no algorithm can reach an error ϵ in minimizing all functions from this class in fewer than $\Omega(n + \sqrt{n(\kappa-1)}\log(1/\epsilon))$ iterations, where $\kappa=L/\mu$ is a surrogate condition number. We compare this lower bound to upper bounds for recently developed methods. We further compare all these bounds in a machine learning setup and conclude that a lot of caution is necessary for an accurate interpretation.

3 - Tradeoffs in Large Scale Learning: Statistical Accuracy vs. Numerical Precision

Sham Kakade, Principal Researcher, Microsoft Research, 1 Memorial Drive, Cambridge, MA, 02142, United States of America, skakade@microsoft.com

In many estimation problems, \eg linear and logistic regression, we wish to minimize an unknown objective given only unbiased samples. Disregarding computational constraints, the minimizer of a sample average — the empirical risk minimizer (ERM) or the M-estimator — is widely regarded as the estimation strategy of choice due to its desirable statistical convergence properties. Our goal is to perform as well as the ERM, on every problem, while minimizing the use of computational resources.

■ TD27

27- Duquesne Room

Markets and Congestion in Power Systems

Cluster: Optimization in Energy Systems

Invited Session

Chair: Jeffrey Linderoth, 1513 University Ave, Madison, WI, 53706, United States of America, linderot@cae.wisc.edu

1 - Quantitative Analysis of Flexibility Services Regulation Frameworks for Distribution Systems

Sebastien Mathieu, Université de Liège, sebastien.mathieu@ulg.ac.be, Damien Ernst, Quentin Louveaux, Bertrand Cornélusse

We study the question of assessing the economic impact of interaction models governing the exchange of flexibility service within electrical distribution systems. We propose several interaction models that we evaluate using an agent-based method where each agent is assumed to maximize their profit through an optimization program. The agents we consider are distribution and transmission system operators, producers and retailers. A comparison over one year highlights the advantages and weaknesses of each interaction model.

2 - Nonatomic Congestion Games in Electricity Markets with Flexible Consumption

Quentin Louveaux, Professor, Université de Liège, 10 Grande Traverse, Liège, 4000, Belgium, q.louveaux@ulg.ac.be, Sebastien Mathieu

The load flexibility allows retailers to game to decrease their energy procurement cost on spot markets like the day-ahead energy market. The talk shows how this demand allocation game can be mapped to a nonatomic congestion game and the implications on the Nash equilibrium. We discuss the price of anarchy as well as the ratio between the prices at different periods in the case of linear offer curves. The bounds are dependent on the number of retailers. Finally we provide a method to compute the price at which the flexibility of the demand side should be remunerated if a retailer is requested to deviate from its Nash equilibrium. This method depends only on data of the spot market that could be made publicly available.

3 - Power Flow Models with Computationally Tractable Joint Chance Constraints

Eric Anderson, University of Wisconsin-Madison, 4430 Rolla Ln., Madison, WI, 53711, United States of America, eanderson4@wisc.edu, James Luedtke, Jeff Linderoth

The current line threshold model for transmission elements places the economics and reliability of single lines above that of system. A system risk measure needs to be developed and constrained so there is a proper trade off between the cost and risk of a given dispatch point. We develop a line risk measure and then constrain system risk. We solve this exactly via nonlinear programming in a static demand scenario and approximately in a demand scenario with a multivariate gaussian distribution. A computational example will be used to discuss the cost-risk frontier.

■ TD28

28- Liberty Room

Global Optimization with Complementarity Constraints

Cluster: Global Optimization

Invited Session

Chair: Joaquim JudiceRetired, Professor, Instituto Telecomunicacoes, Polo 2, Universidade de Coimbra, Coimbra, Portugal, judice@co.it.pt

1 - A Convex Reformulation of Rank-Constrained Optimization Problems

John Mitchell, Professor, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY, 12180, United States of America, mitchj@rpi.edu, Jong Shi Pang, Lijie Bai

Low rank approximations are desirable in many settings. We show that the problem of minimizing a linear or convex quadratic objective function of a matrix subject to linear constraints and an upper bound on the rank is equivalent to a convex conic optimization problem. The reformulation first represents the problem as a semidefinite program with conic complementarity constraints and then lifts the problem to give an equivalent convex conic optimization problem.

2 - A Reformulation of Cardinality Constraints Using a Complementarity-Type Condition

Alexandra Schwartz, TU Darmstadt, Dolivostrafle 15, Darmstadt, Germany, schwartz@gsc.tu-darmstadt.de, Michal Cervinka, Christian Kanzow, Oleg Burdakov

Programs with cardinality constraints are constrained optimization problems, where only a given number of the variables is allowed to be nonzero. We consider a reformulation of the cardinality constraint using binary variables, whose relaxation leads to a mathematical program in continuous variables with a complementarity-type constraint. We discuss the relation between the local and global solutions of the original and the relaxed problem. Additionally, we analyze the theoretical properties of the relaxed problem, which differ from those known for general mathematical programs with complementarity constraints. Finally, we suggest a regularization method for the solution of the relaxed problem and present some numerical results.

3 - Second-Order Cone Quadratic Eigenvalue Complementarity Problem

Joaquim Judice, Retired Professor, Instituto Telecomunicacoes, Polo 2, Universidade de Coimbra, Coimbra, Portugal, judice@co.it.pt, Alfredo Iusem, Hanif Sherali, Valentina Sessa

The Quadratic Eigenvalue Complementarity Problem on the Second-Order Cone (SOCQEiCP) has a solution under reasonable assumptions on the matrices included in its definition. A Nonlinear Programming Problem (NLP) formulation of SOCQEiCP is introduced such that a solution of SOCQEiCP is a global optimal minimum of NLP with a zero optimal value. An enumerative method based on RLT is proposed for solving NLP and its performance is enhanced by combining it with a semi-smooth Newton method.

■ TD29

29- Commonwealth 1

Recent Advances in ADMM I

Cluster: Nonsmooth Optimization

Invited Session

Chair: Xiaoming Yuan, Hong Kong Baptist University, Kowloon Tong, HongKong, China, xmyuan@hkbu.edu.hk

1 - A Majorized ADMM with Indefinite Proximal Terms for Linearly Constrained Convex Optimization

Min Li, Prof., Southeast University, School of Economics and Management, Sipailou 2#, Nanjing, 210096, China, limin@seu.edu.cn, Defeng Sun, Kim-Chuan Toh

This talk presents a majorized alternating direction method of multipliers (ADMM) with indefinite proximal terms for solving linearly constrained 2-block convex composite optimization problems with each block in the objective being the sum of a non-smooth convex function and a smooth convex function. By choosing the indefinite proximal terms properly, we establish the global convergence and O(1/k) ergodic iteration-complexity of the proposed method. The computational benefit of using indefinite proximal terms within the ADMM framework instead of the current requirement of positive semidefinite ones is also demonstrated numerically. This opens up a new way to improve the practical performance of the ADMM and related methods.

2 - Rate of Convergence of some Alternating Direction Methods

Deren Han, Prof., Nanjing Normal University, Nanjing, China, Nanjing, 210023, China, handeren@njnu.edu.cn

In this talk, we consider the convergence rate of ADMM when applying to the convex optimization problems that the subdifferentials of the underlying functions are piecewise linear multifunctions, including LASSO, a well known regression model in statistics as a special case. We prove that due to its inherent polyhedral structure, a recent global error bound holds for this class of problems. Based on this error bound, we derive the linear rate of convergence for ADMM. We also consider the proximal based ADMM, and derive its linear convergence rate.

3 - Block-Wise Alternating Direction Method of Multipliers for Multiple-Block Convex Programming

Xiaoming Yuan, Hong Kong Baptist University, Kowloon Tong, HongKong, China, xmyuan@hkbu.edu.hk, Bingsheng He

It has been shown that the direct extension of the alternating direction method of multipliers (ADMM) to a multiple-block case where the objective function is the sum of more than two functions is not necessarily convergent. For the multiple-block case, a natural idea is to artificially group the objective functions and the corresponding variables as two groups and then apply the original ADMM directly – the block-wise ADMM is accordingly named because each of the resulting ADMM subproblems may involve more than one function in its objective. We discuss how to further decompose the block-wise ADMM's subproblems and obtain easier subproblems, while the convergence can still be ensured.

■ TD30

30- Commonwealth 2

Approximation and Online Algorithms VII

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Howard Karloff, 310 West 85th St., New York, NY, 10024, United States of America, howard@cc.gatech.edu

1 - Simple Approximation Algorithms for MAX SAT

Matthias Poloczek, Cornell University, 272 Rhodes Hall, 136 Hoy Road, Ithaca, NY, 14853, United States of America, poloczek@cornell.edu, David Williamson, Anke van Zuylen, Georg Schnitger

We present simple linear-time algorithms that obtain 3/4-approximations for the maximum satisfiability problem (MAX SAT). In particular, their performance guarantees are comparable to Yannakakis' algorithm based on flows and LP (1994) or the LP-rounding algorithm of Goemans and Williamson (1994). Our first algorithm considers the variables in an arbitrary ordering and makes a random decision for each variable instantly and irrevocably. Secondly, we present a deterministic algorithm that performs two passes over the input. An interesting aspect is that this additional run over the input allows us to bypass an inapproximability result for deterministic greedy algorithms of Poloczek (2011).

2 - Entropy, Optimization and Counting

Nisheeth Vishnoi, EPFL IC IIF THL3, INJ 130 - Station 14, Lausanne, 1025, Switzerland, nisheeth.vishnoi@epfl.ch, Mohit Singh

We study the problem of computing max-entropy distributions over a discrete set of objects subject to observed marginals. While there has been a tremendous interest in such distributions in numerous areas, a rigorous study of how to compute such distributions has been lacking. We start by giving a structural result which shows that such succinct descriptions exist under very general conditions despite the fact the underlying set can be exponential. Subsequently, we give a meta-algorithm that can efficiently (approx.) compute max-entropy distributions provided one can efficiently (approx.) count the underlying discrete set. Conversely, we show how algorithms that compute max-entropy distributions can be converted into counting algorithms.

3 - Variable Selection is Hard

Howard Karloff, 310 West 85th St., New York, NY, 10024, United States of America, howard@cc.gatech.edu, Dean Foster, Justin Thaler

Consider the task of a machine-learning system faced with voluminous data on m individuals. How can the algorithm find a small set of features that best describes the individuals? We study the simple case of linear regression, in which a user has a matrix B and a vector y, and seeks a vector x, with as few nonzeroes as possible, such that Bx is approximately equal to y, and we call it SPARSE REGRESSION. We give a general hardness proof that (subject to a complexity assumption) no polynomial-time algorithm can give good performance (in the worst case) for SPARSE REGRESSION, even if it is allowed to include more variables than necessary, and even if it need only find an x such that Bx is relatively far from y.

Tuesday, 4:35pm - 5:25pm

■ TE01

01- Grand 1

A Gentle, Geometric Introduction to Copositive Optimization

Cluster: Plenary

Invited Session

Chair: Fatma Kilinc-Karzan, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, fkilinc@andrew.cmu.edu

1 - A Gentle, Geometric Introduction to Copositive Optimization

Sam Burer, Professor, University of Iowa, S346 Pappajohn Business Building, Iowa City, IA, 52246, United States of America, samuel-burer@uiowa.edu

This talk illustrates the fundamental connection between nonconvex quadratic optimization and copositive optimization—-a connection that allows the reformulation of nonconvex quadratic problems as convex ones in a unified way. We focus on examples having just a few variables or a few constraints for which the quadratic problem can be formulated as a copositive-style problem, which itself can be recast in terms of linear, second-order-cone, and semidefinite optimization. A particular highlight is the role played by the geometry of the feasible set.

■ TE02

02- Grand 2

Fast Distributed Algorithms for Multi-Agent Optimization

Cluster: Plenary
Invited Session

Chair: Lorenz Biegler, Carnegie Mellon University, Pittsburgh, United States of America, biegler@cmu.edu

1 - Fast Distributed Algorithms for Multi-Agent Optimization

Asu Özdaglar, Professor, Massachusetts Institute of Technology, 77 Massachusetts Avenue, 32-D630, Cambridge, MA, 02139, United States of America, asuman@mit.edu

Motivated by todayís data processing needs over large networks with local collection and processing of information, we consider a multi agent optimization problem where a network of agents collectively solves a global optimization problem with the objective function given by the sum of locally known convex functions. We present new distributed algorithms drawing on two different approaches: The first is based on Alternating Direction Method of Multipliers (ADMM), which is a classical method for sequentially decomposing optimization problems with coupled constraints. We show that convergence rate of distributed ADMM-based algorithms is O(1/k) (where k is the iteration number), which is faster than the O(1/sqrt(k)) rate of subgradient-based methods, and highlight the dependence on the network structure. The second approach develops an incremental Newton (IN) method, which accesses problem data sequentially. Under strong convexity of local objective functions, a gradient growth condition, and with proper stepsize rules, we show that convergence rate of the IN method is linear.

Wednesday, 9:00am - 9:50am

■ WA01

01- Grand 1

Coordinate Descent Algorithms

Cluster: Plenary
Invited Session

Chair: Jorge Nocedal, Northwestern University, Room M326, Technological Institute, 2145 Sheridan Road, Evanston, IL, United States of America, j-nocedal@northwestern.edu

1 - Coordinate Descent Algorithms

Stephen Wright, University of Wisconsin-Madison, University of Wisconsin-Madison, Madison, WI, United States of America, swright@cs.wisc.edu

Coordinate descent algorithms solve optimization problems by successively searching along coordinate directions or coordinate hyperplanes. They have been used in applications for many years, and their popularity continues to grow because of their usefulness in data analysis, machine learning, and other areas of current interest. This talk will describe the fundamentals of the coordinate descent approach, together with its variants and extensions. Convergence properties will be described, mostly with reference to convex objectives. We pay particular attention to a certain problem structure that arises commonly in machine learning applications, showing that efficient implementations of accelerated coordinate descent algorithms are possible for such structures. We also describe parallel variants and discuss their convergence properties under several models of parallel execution.

Wednesday, 10:20am - 11:50am

■ WB01

01- Grand 1

Recent Advances in Optimization Software

Cluster: Implementations and Software
Invited Session

Chair: Hans Mittelmann, Professor, Arizona State University, Box 871804, Tempe, Az, 85287-1804, United States of America, mittelma@asu.edu

1 - The State-of-the-Art in Optimization Software

Hans Mittelmann, Professor, Arizona State University, Box 871804, Tempe, Az, 85287-1804, United States of America, mittelma@asu.edu

Based on our ongoing benchmarking effort the current capabilities of selected open source and commercial optimization software will be highlighted.

2 - Reoptimization Techniques in MIP Solvers

Jakob Witzig, Zuse-Institute-Berlin, Takustr. 7, Berlin, 14195, Germany, witzig@zib.de

Recently, there have been many successful applications of optimization algorithms that solve a sequence of quite similar mixed-integer programs (MIPs) as subproblems. Traditionally, each problem in the sequence is solved from scratch. In this talk we consider reoptimization techniques that try to benefit from information obtained by solving previous problems of the sequence. We focus on the case that subsequent MIPs differ only in the objective function or that the feasible region is reduced. We propose extensions of the very complex branch-and-bound algorithms employed by general MIP solvers based on the idea to ``warmstart" using the final search frontier of the preceding solver run.

3 - On Recent Improvements in the Interior-Point Optimizer in MOSEK

Andrea Cassioli, Product Manager, MOSEK ApS, Fruebjergvej 3 Symbion Science Park, Box, Copenhagen, Se, 2100, Denmark, andrea.cassioli@mosek.com

In this talk we will discuss the recent advances in the interior-point optimizer in the upcoming version 8 release of MOSEK. The advances include: (1) an improved pre-solver; (2) a more stable semi-definite optimization solve; (3) an automatic dualizer for conic quadratic optimization problems; (4) the possibility to reformulate automatically QPs and QCQPs in conic form. We will present computational tests to benchmark the new implementation against the previous one.

■ WB02

02- Grand 2

Nonlinear Optimization for Power Systems

Cluster: Optimization in Energy Systems
Invited Session

Chair: Javad Lavaei, Assistant Professor, Columbia University, New York, New York, United States of America, lavaei@ee.columbia.edu

1 - Convexification of Optimal Power Flow Problem

Ramtin Madani, PhD Candidate, Columbia University, 3333 Broadway, Apt D12J, New York, 10031, United States of America, madani@ee.columbia.edu, Morteza Ashraphijuo, Abdulrahman Kalbat, Javad Lavaei

The flows in an electrical grid are described by nonlinear AC power flow equations. This talk is concerned with finding a convex formulation of the power flow equations using semidefinite programming (SDP). Addressing this problem facilitates performing several fundamental, yet challenging tasks such as economical dispatch and state estimation for power networks. Based on the sparsity of the network structure, a parallel algorithm for large-scale SDP problems will also be proposed.

2 - Alternating Direction Method of Multipliers for Sparse Semidefinite Programs

Abdulrahman Kalbat, Columbia University, 808 Schapiro CEPSR, 530 west 120th st, New York, NY, 10027, United States of America, ak3369@columbia.edu, Javad Lavaei

A parallel algorithm for solving an arbitrary sparse semidefinite program (SDP) is developed based on the alternating direction method of multipliers. The proposed algorithm has a guaranteed convergence under very mild assumptions. Each iteration of this algorithm has a simple closed-form solution, and consists of matrix multiplication and eigenvalue decomposition over matrices whose sizes are not greater than the treewdith of the sparsity graph of the SDP problem. The cheap iterations of the proposed algorithm enable solving real-world large-scale conic optimization problems.

3 - A Spatial Branch-and-Bound Method for ACOPF

Chen Chen, Graduate Student, UC Berkeley, 450 Sutardja Dai Hall #61, Berkeley, CA, 94730-1764, United States of America, chenchen@berkeley.edu, Alper Atamturk, Shmuel Oren

We study the Alternating Optimal Power Flow (ACOPF) problem, which is an electric generation dispatch problem. ACOPF can be formulated as a nonconvex Quadratically Constrained Quadratic Program with bounded complex variables. We propose a spatial branch-and-bound approach to solving the formulation. We introduce valid inequalities to strengthen the standard semidefinite programming relaxation, enabling branching on complex entries of the decision matrix. We also propose new branching rules and develop closed-form bound tightening procedures specific to ACOPF. Various algorithmic configurations are tested computationally on instances from the literature with small root gaps as well as more difficult new instances based on IEEE test cases.

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■ WB03

03- Grand 3

Handling Infeasibility, Sparsity, and Symmetry in Combinatorial Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Marc Pfetsch, Prof., TU Darmstadt, Department of Mathematics, Dolivostr. 15, Darmstadt, 64293, Germany, pfetsch@mathematik.tu-darmstadt.de

1 - Analyzing Infeasibility in Flow Networks

Imke Joormann, TU Darmstadt, Department of Mathematic, Dolivostrasse 15, Darmstadt, D-64293, Germany, joormann@mathematik.tu-darmstadt.de, Marc Pfetsch

We study means to repair infeasibility in network flow problems with supplies and demands. After examining some characteristics, the boundary of the hardness is analyzed: We show non-approximability and hardness of different approaches, give polynomially solvable special cases and derive approximation and Fixed Parameter algorithms.

2 - Branch & Cut Methods for Exact Sparse Recovery

Andreas Tillmann, TU Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, tillmann@mathematik.tu-darmstadt.de, Marc Pfetsch

While there are many heuristics for sparse recovery (the NP-hard task of finding the sparsest exact or approximate solution to an underdetermined linear equation system), guaranteeing or verifying their success is often NP-hard itself. This motivates tackling the sparse recovery problem directly, e.g., with methods from combinatorial optimization. We discuss Branch & Cut schemes for this purpose, based on set-cover-based binary program reformulations, and report new findings, connections to other interesting problems, and numerical results.

3 - Polyhedral Symmetry Handling via Fundamental Domains

Christopher Hojny, TU Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, hojny@mathematik.tu-darmstadt.de, Marc Pfetsch

Symmetry in discrete optimization problems is known to have a negative influence on the performance of branch-and-bound procedures. In this talk, we extend a polyhedral approach to reduce the impact of symmetry. This work is based on Friedman's investigations on fundamental domains for integer programs. We develop a generalization to symmetry breaking polytopes and study the symmetry group's impact on the structure of symmetry breaking polytopes.

■ WB04

04- Grand 4

Advances and Applications in Conic Optimization Part II

Cluster: Conic Programming

Invited Session

Chair: Akiko Yoshise, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki, Tsukuba, Ib, 305-8573, Japan, yoshise@sk.tsukuba.ac.jp

1 - Nonlinear Doubly Nonnegative Cone Problems: Strict Complementarity and Optimality Conditions

Bolor Jargalsaikhan, University of Groningen, Hiddemaheerd 127, Groningen, 9737JZ, Netherlands, b.jargalsaikhan@rug.nl, Jan Rückmann

Doubly nonnegative cone (DNN) is intersection of positive semidefinite cone and nonnegative cone. Optimality conditions for nonlinear positive semidefinite programs has been studied. Unlike positive semidefinite case, DNN is not self-dual and its dual cone is not facially exposed. We study optimality conditions for nonlinear DNN problems. In particular, we investigate strict complementarity condition specialized to DNN cone and its application on second order necessary optimality conditions for nonlinear DNN problems.

2 - Improved LP-based Algorithms for Testing Copositivity and Other Properties

Akihiro Tanaka, University of Tsukuba, tanaka.akihiro@sk.tsukuba.ac.jp, Akiko Yoshise

Tanaka and Yoshise (2015) introduced some subcones of the copositive cone and showed that one can detect whether a given matrix belongs to one of those cones by solving linear optimization problems. They also provided an LP-based algorithm for testing copositivity using the subcones. In this talk, we investigate the properties of the subcones more precisely and propose improved algorithms for testing these properties and copositivity.

3 - Application of Inner-Iteration Krylov Subspace Methods to Interior-Point Methods for Linear Programs

Yiran Cui, Department of Computer Science, University College London, Gower Street, London, WC1E 6BT, United Kingdom, y.cui.12@ucl.ac.uk, Keiichi Morikuni, Takashi Tsuchiya, Ken Hayami

We present an implementation of the interior-point algorithm for linear programming based on the Krylov subspace methods for least squares problems. We employ an inner-iteration preconditioner recently developed by the authors to deal with severe ill-conditioning of linear equations in the final stage of iterations. The advantage of our method is that it does not break down even when previous direct methods do. Also, we save computation time and storage compared to previous explicit preconditioners.

■ WB05

05- Kings Garden 1

Recent Advances in Computational Optimization I

Cluster: Nonlinear Programming

Invited Session

Chair: William Hager, Professor, University of Florida, Department of Mathematics, Gainesville, FL, 32611, United States of America, hager@ufl.edu

Co-Chair: Gerardo Toraldo, Professor, University of Naples Federico II, Department of Mathematics and Applications, Via Cintia, Monte S. Angelo, Naples, I-80126, Italy, toraldo@unina.it

1 - On Steplength Rules in Gradient Methods

Gerardo Toraldo, Professor, University of Naples Federico II, Department of Mathematics and Applications, Via Cintia, Monte S. Angelo, Naples, I-80126, Italy, toraldo@unina.it, Salvatore Amaradio, Daniela di Serafino, Valeria Ruggiero, Luca Zanni

In the last 25 years the interest in gradient methods has been renewed after the publication of the work by Barzilai and Borwein. Since then, several strategies have been proposed for choosing the steplength, opening the way to novel first-order methods for continuous nonlinear optimization. These methods have become a valid and useful tool for large-scale problems, e.g. in machine learning and data mining. In this talk we consider some steplength rules and present their spectral properties, which provide insight into the computational effectiveness and regularization properties of the resulting gradient methods. Computational experiments supporting the theoretical analysis are provided.

2 - An Inexact Alternating Direction Algorithm for Separable Convex Optimization

Hongchao Zhang, Professor, Louisiana State University, Baton Rouge, LA, United States of America, hozhang@math.lsu.edu, William Hager, Maryam Yashtini

We will introduce an inexact alternating direction algorithm with variable stepsize for solving separable convex optimization. This algorithm generalizes the Bregman operator splitting algorithm with variable stepsiz (BOSVS) and allows to solve the convex subproblems to an adaptive accuracy. Global convergence and some preliminary numerical results will be discussed in this talk.

3 - On Acceleration Schemes and the Choice of Subproblem's Constraints in Augmented Lagrangian Methods

Ernesto G. Birgin, Professor, University of São Paulo, Department of Computer Science, São Paulo, SP, 05508-090, Brazil, egbirgin@ime.usp.br, Luis Felipe Bueno, José Mario Marttínez

Algencan is an Augmented Lagrangian (AL) method that solves a sequence of bound-constrained subproblems. With the aim of improving the practical performance of Algencan, an acceleration scheme, that tries to solve a KKT system by Newton's method in-between the AL iterations, was developed. For problems with only equality constraints, the acceleration scheme by itself presented an outstanding performance when compared against state-of-the-art NLP solvers and considering all equality-constrained problems from the CUTEst collection. This state of facts suggests that an AL method with equality-constrained subproblems may be developed.

■ WB06

06- Kings Garden 2

Combinatorial Optimization in Social Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Baski Balasundaram, Associate Professor, Oklahoma State University, 322 Engineering North, Stillwater, OK, 74078, United States of America, baski@okstate.edu

1 - Weighted Target Set Selection

Rui Zhang, University of Maryland-College Park, The Smith School Of Business, College Park, MD, 20742, United States of America, ruizhang@rhsmith.umd.edu, S. Raghavan

The Target Set Selection (TSS) problem is a fundamental problem about the diffusion of influence in social networks. In our work, we consider the weighted version of it (the WTSS problem). The weights model the fact the cost to activate different nodes can vary. The TSS problem is known to be NP-hard, and earlier work has focused on approximation. Motivated by the desire to develop mathematical programming approaches to solve the WTSS problem, we focus on developing a strong formulation for the WTSS problem. We present a tight and compact extended formulation for the WTSS problem on trees. Furthermore, based on this strong formulation, a branch and cut approach is proposed for general networks. Computational results will be presented.

2 - On Imposing Connectivity Constraints in Integer Programs

Austin Buchanan, Texas A&M University, TAMU-3131, College Station, United States of America, buchanan@tamu.edu, Yiming Wang, Sergiy Butenko

In many clustering and network analysis applications, one searches for a connected subset of vertices that exhibits other desirable properties. To this end, this paper studies the connected subgraph polytope of a graph, which is the convex hull of subsets of vertices that induce a connected subgraph. We determine precisely when vertex separator inequalities induce facets and when they induce all nontrivial facets. These vertex separator inequalities are of particular interest because they have been successfully used to enforce connectivity in application. We also study the complexity of lifting, and provide closed-form descriptions of the connected subgraph polytopes of stars and paths.

3 - On the 2-club Polytope of Graphs

Baski Balasundaram, Associate Professor, Oklahoma State University, 322 Engineering North, Stillwater, OK, 74078, United States of America, baski@okstate.edu, Illya Hicks, Foad Mahdavi Pajouh

A k-club is a subset of vertices in a graph that induce a subgraph of diameter at most k, where k is a positive integer. The k-club model for k>=2 is interesting to study from a polyhedral perspective as the property is not hereditary on induced subgraphs. This article introduces a new family of facet defining inequalities for the 2-club polytope. The complexity of separation over this new family of inequalities is shown to be NP-hard. An exact formulation of this separation problem and a greedy separation heuristic are also proposed. The effectiveness of these new facets as cutting planes, and the difficulty of solving the separation problem are then investigated via computational experiments on a test-bed of benchmark instances.

■ WB07

07- Kings Garden 3

Advances in Integer Programming IV

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Alper Atamturk, UC Berkeley, Sutardja Dai Hall, Berkeley, CA, United States of America, atamturk@berkeley.edu

1 - k-Dimensional Lattice Closure

Oktay Gunluk, IBM Research, 1101 Kitchawan Road, Yorktown Heights, NY, United States of America, gunluk@us.ibm.com, Diego Moran, Sanjeeb Dash

We define the k-dimensional lattice closure of a polyhedral set to be the intersection of the convex hulls of all possible relaxations of the set with k integer variables. More precisely, given a mixed integer set with integer variables x, a relaxation of this form is obtained by (i) choosing up to k integer vectors c_1, ...,c_k, (ii) requiring dot products < c_1,x >,...,< c_k,x > to be integral, and (iii) dropping the integrality requirement on x. The k-dimensional lattice closure is equal to the split closure when k=1 and equals the crooked cross cut closure when k=2. The k-dimensional lattice closure of a (rational) polyhedral mixed integer set is known to be polyhedral when k=1, and we extend this result to larger values of k.

2 - Second-order Cone Presolving Techniques in Mixed-integer Optimization

Henrik Alsing Friberg, Industrial PhD Student, MOSEK ApS, Fruebjergvej 3, Copenhagen O, 2100, Denmark, henrik.alsing.friberg@mosek.com, Alper Atamturk

Inspired by Savelsbergh (1994), we extend basic analysis and probing techniques to mixed-integer second-order cone optimization. We show how the coefficients of a second-order cone constraint can be tightened, and how simple forms of facial reduction can be detected efficiently.

3 - Two Classes of Valid Inequalities for the DC Optimal Transmission Switching Problem

Burak Kocuk, Georgia Tech, 765 Ferst Drive, NW, Atlanta, GA, 30318, United States of America, burak.kocuk@gatech.edu, Santanu Dey, Andy Sun

As the modern transmission control and relay technologies evolve, transmission line switching has become an important option in power system operators' toolkits. Much research has focused on developing heuristic algorithms while the mathematical theory of the underlying optimization problem has not been well studied. In this work, we propose two classes of valid inequalities. The first class is based on a cycle-induced relaxation where we characterize the convex hull and use it to generate valid inequalities. The second class is based on Wheatstone Bridges, the key elements in congestion analysis. We show that separation can be done in polynomial time for both classes. Extensive computational experiments show promising results.

■ WB08

08- Kings Garden 4

Scheduling

Cluster: Combinatorial Optimization

Invited Session

Chair: Andreas Wiese, MPI for Informatics, Campus E 1.4, Saarbruecken, 66123, Germany, awiese@mpi-inf.mpg.de

1 - A Fully Polynomial-Time Approximation Scheme for Speed Scaling with Sleep State

Antonios Antoniadis, MPI for Informatics, Germany, aantonia@mpi-inf.mpg.de, Chien-Chung Huang, Sebastian Ott

In this talk, we consider classical deadline-based preemptive scheduling of jobs in a computing environment equipped with both dynamic speed scaling and sleep state capabilities: Each job is specified by a release time, a deadline and a processing volume, and has to be scheduled on a single, speed-scalable processor that is supplied with a sleep state. The goal is to output a feasible schedule that minimizes the energy consumption. The currently best known upper and lower bounds are a 4/3-approximation algorithm and NP-hardness. We describe how to close the aforementioned gap between the upper and lower bound on the computational complexity of the problem by presenting a fully polynomial-time approximation scheme for it.

2 - Deadline Scheduling of Conditional DAG Tasks

Vincenzo Bonifaci, Researcher, Consiglio Nazionale delle Ricerche, Via dei Taurini 19, Rome, RM, 00185, Italy, vincenzo.bonifaci@iasi.cnr.it, Sanjoy Baruah, Alberto Marchetti-Spaccamela

Directed acyclic graphs (DAGs) are a standard model for representing concurrent tasks. The nodes of the DAG correspond to sequential portions of the task, and the arcs of the DAG encode precedence constraints. We propose and evaluate an extension of this model to allow conditional execution of task portions, as well as intra-task concurrency. The Global Earliest Deadline First (GEDF) scheduling of systems represented in this generalized model is studied, and a polynomial time GEDF-schedulability test with constant speedup bound is derived. With regards to GEDF scheduling it is shown that there is no penalty, in terms of worse speedup factor, in generalizing the non-conditional DAG task model in this manner.

3 - An O(m2og m)-Competitive Algorithm for Online Machine Minimization

Kevin Schewior, TU Berlin, Sekretariat MA 5-1, Strafle des 17. Juni 136, Berlin, 10623, Germany, schewior@math.tu-berlin.de, Nicole Megow, Lin Chen

We consider preemptively scheduling jobs with deadlines that arrive online over time. The task is to determine a feasible schedule on a minimum number of machines. We present a general O(m≤log m)-competitive algorithm, where m is the optimal number of machines in an offline solution. This is the first algorithm whose guarantee depends solely on m. The existence of such an algorithm was open since the seminal work by Phillips et al. (STOC 1997). To develop the algorithm, we investigate two complementary special cases of the problem depending on the nesting structure of the processing intervals, namely, laminar and agreeable instances. For them, we provide an O(log m)-competitive and an O(1)-competitive algorithm, respectively.

■ WB09

09- Kings Garden 5

Robust Optimization Methodology

Cluster: Robust Optimization

Invited Session

Chair: Melvyn Sim, Professor, Singapore, melvynsim@gmail.com

1 - A Study of Risk-Averse Two-Stage Stochastic Program with Distribution Ambiguity

Yongpei Guan, Associate Professor, University of Florida, Weil Hall 303, Gainesville, FL, 32611, United States of America, guan@ise.ufl.edu, Chaoyue Zhao

In this research, we investigate the data-driven risk-averse two-stage stochastic program with a new class of probability metrics. We reformulate the problem as a traditional two-stage robust optimization problem for the discrete distribution case and develop a sampling approach for the continuous distribution case. For both cases, we prove that the risk-averse two-stage stochastic problem converges to its risk-neutral counterpart at an exponential rate.

2 - Multistage Robust Mixed Integer Optimization with Adaptive Partitions

Iain Dunning, PhD Candidate, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-149, Cambridge, MA, 02139, United States of America, idunning@mit.edu, Dimitris Bertsimas

We present a new method for multistage adaptive mixed integer optimization (AMIO) problems that extends previous work on finite adaptability. The approach analyzes the optimal solution to a non-adaptive version of an AMIO problem and uses this information to construct partitions in the uncertainty set. We repeat this process iteratively to further improve the objective. We provide theoretical motivation for this method, and detail how to apply it to multistage AMIO problems to respect the natural non-anticipativity constraints. We provide lower and upper bounds on the solution quality, and demonstrate in computational experiments that the method can provide substantial improvements over a non-adaptive solution and existing methods.

3 - Distributionally Robust Counterpart over Ambiguity Sets with Semi-infinite Expectation Constraints

Zhi Chen, Department of Decision Sciences, PhD B1-02 Biz2 Building, NUS Business School, Singapore, 117592, Singapore, chenzhi@u.nus.edu, Melvyn Sim, Huan Xu

We investigate semi-infinite ambiguity sets that involve expectation constraints besides generalized moments and support information. We study the associated intractable distributionally robust counterpart by considering approximate ambiguity sets with finite expectation constraints. Based on worst-case distribution, we demonstrate an algorithm that improves the approximation gradually. We present expressive examples of this class of ambiguity sets, and show examples where authenticity of the worst-case distribution is relatively easy to verify so that the algorithm is efficient.

■ WB10

10- Kings Terrace

New Twists in Risk Minimization Modeling

Cluster: Finance and Economics

Invited Session

Chair: Jun-ya Gotoh, Professor, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, jgoto@indsys.chuo-u.ac.jp

1 - Buffered Probability of Exceedance: Properties and Applications in Finance

Stan Uryasev, University of Florida, Gainesville, FL, 32611, United States of America, uryasev@ufl.edu, Alexander Mafusalov, Matthew Norton

This paper investigates a new probabilistic characteristic called buffered probability of exceedance (bPOE). bPOE counts tail outcomes averaging to some specific threshold value. Minimization of bPOE can be reduced to convex and Linear Programming. We will discuss two applications of bPOE concept. The first application considers the Cash Matching of a Bond Portfolio. We minimize bPOE that assets exceed liabilities. The second application uses bPOE in data mining. AUC characteristic standardly used to evaluate classification models. We explored so called Buffered AUC (bAUC) as a counterpart of the standard AUC.

2 - Two Perspectives on Robust Empirical Optimization

Jun-ya Gotoh, Professor, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, jgoto@indsys.chuo-u.ac.jp, Michael Jong Kim, Andrew E. B. Lim

In this talk, we consider a robust formulation for empirical optimization. Our main finding is that robust empirical optimization is essentially equivalent to two different problems with seemingly different concerns - an empirical mean-variance problem and the problem of maximizing a (probabilistic) lower bound on out-of-sample performance. The connection to the empirical mean-variance problem is shown using a simple Taylor expansion, and the connection to optimizing a lower bound on the out-of-sample performance is shown using an empirical version of Bennett's inequality.

3 - Optimizing Over Coherent Risk Measures for Binary Classification

Akiko Takeda, Associate Professor, The University of Tokyo, Department of Mathematical Informatics, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan, takeda@mist.i.u-tokyo.ac.jp, Dimitris Bertsimas

Binary classification models are often formulated as minimization of loss functions (measures of misclassification) under a norm constraint. Recent several works relate loss functions to financial risk measures. We propose binary classification models minimizing coherent risk measures by robust optimization formulation. Setting a new uncertainty set leads to a new binary classification model. The numerical experiments imply that coherent risk measure minimization performs better than the non-coherent variant for classification.

■ WB11

11- Brigade

Assignment Type Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Joris Van de Klundert, Professor, Erasmus University Rotterdam, Burg Oudlaan 50, M5-29, Rotterdam, 3000 DR, Netherlands, vandeklundert@bmg.eur.nl

1 - Revisiting the Branch & Cut Method for the Axial and Planar Assignment Problem

Stathis Plitsos, PhD Candidate, Athens University of Economics and Business, 47A Evelpidon Str. & 33 Lefkados Str., Athens, 113 62, Greece, stathisp@aueb.gr, Dimitrios Magos, Ioannis Mourtos

We revisit the Branch & Cut approach for the axial and planar assignment problems, after adopting a unifying approach and deploying problem-specific cuts, branching rules and tabu-search, plus a generic feasibility-pump variant that integrates constraint propagation and cuts during the pumping cycles (i.e., cuts facilitate both lower and upper bound improvement). Experimentation on large-scale instances shows that our approach reduces the time to optimality and solves memory-wise intractable instances compared to a commercial solver.

2 - Hypergraph Assignments

Ralf Borndoerfer, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, borndoerfer@zib.de, Olga Heismann

The hypergraph assignment problem generalizes the assignment problem from bipartite graphs to what we call bipartite hypergraphs; it is motivated by applications in railway vehicle rotation planning. The problem is NP-hard even for hyperedge size two, but can be solved in polynomial time for certain cost functions. Its polyhedral structure includes a class of generalized odd set inequalities that are also valid for the set packing problem. The expected cost of a random hyperassignment that uses half of the possible hyperedges in a complete partitioned hypergraph with hyperedge size two and i.i.d. exponential random variables with mean 1 as hyperedge costs lies between 0.3718 and 1.8310.

3 - The Adaptive Operating Room Schedule with Overtime Cost: An Application of Knapsack Problem

Joris Van de Klundert, Professor, Erasmus University Rotterdam, burg oudlaan 50, M5-29, rotterdam, 3000 DR, Netherlands, vandeklundert@bmg.eur.nl, Guanlian Xiao, Willem Van Jaarsveld

In practice, the complexity of operating room scheduling importantly stems from its stochastic nature, which often leads to dynamic adjustments. Scientific literature on such adaptive scheduling approaches is scarce. We formally define practically relevant adaptive scheduling problems and corresponding adaptive policies, introducing the concept of committing. The core of the adaptive policies is formed by a pseudopolynomial algorithm to solve a general class of static stochastic operating room scheduling problems. We present extensive computational analysis, based on data from the largest academic medical center in The Netherlands, and show that the benefits over static ones are significant.

■ WB12

12- Black Diamond

Integer Programming Applications in Transportation and Logistics

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Martine Labbé, Professor, Université Libre de Bruxelles, Bd. du Triomphe, CP 212, Brussels, 1050, Belgium, mlabbe@ulb.ac.be

1 - A Computationally-Tractable Stochastic Integer Program for the Single Airport Ground Holding Problem

Alex Estes, University of Maryland-College Park, 4423 Math Building, University of Maryland, College Park, MD, 20740, United States of America, asestes1@gmail.com, Michael Ball

We present a multistage stochastic integer programming model to address the problem of assigning delays to flights when demand at an airport exceeds capacity. Our model extends an integer program which solves the static single airport ground holding problem, so that our model considers some dynamic aspects of the problem which are not included in the static model. We provide conditions which guarantee that the SIP has an integral extreme point and we provide computational results which demonstrate the value of our model over the static model, as well as the computational tractability of our model.

2 - Efficient use of Airspace through Monetary Incentives

Étienne Marcotte, Postdoctoral Researcher, Université Libre de Bruxelles, Boulevard du Triomphe, CP 212, Brussels, 1050, Belgium, emarcott@ulb.ac.be, Martine Labbè

We consider the problem of alleviating congestion in the European airspace through the modulation of the service charges imposed by the Air Navigation Service Providers [ANSP] on the airspace users. This is a bilevel optimization problem which can be formulated using a mixed integer programming representation, which we present. A heuristic based on Variable Neighborhood Descent [VND] is introduced to obtain approximate solutions of this model on real-life instances, which are often too large to be solved using linear programming techniques.

■ WB13

13- Rivers

Formulations, Representations, and Applications in Conic Programming

Cluster: Conic Programming

Invited Session

Chair: Tomohiko Mizutani, Tokyo Institute of Technology, 2-12-1-W9-69, Ookayama, Meguro-ku, Tokyo, 152-8552, Japan, mizutani.t.ab@m.titech.ac.jp

1 - Regularized Multidimensional Scaling with Radial Basis Functions

Sohana Jahan, University of Southampton, School of Mathematics, Southampton, United Kingdom, sj1g12@soton.ac.uk, Hou-Duo Qi

Multi-Dimensional Scaling(MDS) with Radial Basis Function(RBF) is very important method for dimension reduction. A key issue that has not been well addressed in MDS-RBF is effective selection of centers of RBF. We treat this selection problem as multi-task learning problem and employ (2,1)-norm to regularize the original MDS-RBF objective function. We propose its two reformulations: Diagonal and Spectral, which can be solved through iterative block-majorization method. Numerical experiments show improved performance of our models over the original.

2 - Convex Cone with Semidefinite Representable Sections

Anusuya Ghosh, Research Scholar, Indian Institute of Technology Bombay, D 170, Hostel 11, IIT Bombay, IE&OR Lab, Old CSE Building, IIT Bombay, Mumbai, MH, 400 076, India, ghosh.anusuya007@gmail.com, Vishnu Narayanan

We contribute sufficient conditions for semidefinite representability of convex cone considering its sections. The r-sections of convex cone are semidefinite representable (SDR) iff its intersection by (r+1)-flat are SDR. If a convex set K is SDR at a point p in it, then cone(p,K) is SDR. The intersection of convex sets X and Y is a neighbourhood of p relative to Y, if Y is SDR and Y is contained in cone(p,X).

3 - Spectral Clustering by Ellipsoid and its Connection to Separable Nonnegative Matrix Factorization

Tomohiko Mizutani, Tokyo Institute of Technology, 2-12-1-W9-69, Ookayama, Meguro-ku, Tokyo, 152-8552, Japan, mizutani.t.ab@m.titech.ac.jp

We propose a variant of the normalized cut algorithm for spectral clustering. The algorithm shares similarity with the ellipsoidal rounding algorithm for separable nonnegative matrix factorization. The normalized cut algorithm has the issue that the choice of initial points affects the construction of clusters since K-means is incorporated in it, whereas the algorithm proposed here does not. We report experimental results to show the performance of the algorithm.

■ WB14

14- Traders

Privacy in Games

Cluster: Game Theory

Invited Session

Chair: Balasubramanian Sivan, Microsoft Research, One Microsoft Way, Redmond, WA, 98052-6399, United States of America, balu2901@gmail.com

1 - Privacy and Truthful Equilibrium Selection in Aggregative Games

Rachel Cummings, PhD Student, California Institute of Technology, 1200 E California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, rachelc@caltech.edu, Michael Kearns, Aaron Roth, Zhiwei Steven Wu

We study large multi-dimensional aggregative games, which generalize anonymous games and weighted congestion games, and we solve the equilibrium selection problem in a strong sense. We give an efficient weak mediator: a mechanism which has only the power to listen to reported types and provide non-binding suggested actions, such that (a) it is an asymptotic Nash equilibrium for every player to truthfully report their type to the mediator and follow its suggested action; and (b) when players do so, they end up coordinating on a particular asymptotic pure strategy Nash equilibrium of the induced complete information game. We achieve this by giving an efficient differentially private algorithm for computing a Nash equilibrium in such games.

2 - Private Convex Programming Yields Truthful Auctions

Aaron Roth, Assistant Professor, University of Pennsylvania, aaroth@cis.upenn.edu, Justin Hsu, Zhiyi Huang, Zhiwei Steven Wu

An electricity provider faces demand that might rise above its ability to generate power. Rather than resorting to brown-outs, the utility will shut off the air-conditioners of individual buildings remotely. Using this ability, they might be able to coordinate shut-offs so that nobody is ever uncomfortable, but so that peak electricity usage never rises above power production. This optimization introduces a privacy concern: the utility now makes decisions as a function of customers reported behavior. Is there a way to protect the privacy of consumers? Can we also elicit costs truthfully? We show that the answer is "yes" to this problem, and to a broad class of welfare maximization problems that can be posed as convex programs.

3 - Equilibrium Selection in Large Games via Private Mediators

Jonathan Ullman, Junior Fellow, Simons Society of Fellows, Columbia University, 450 Computer Science Bldg, 1214 Amsterdam Ave, New York, NY, 10027, United States of America, jullman@gmail.com

We study the problem of implementing equilibria of complete information games as ex-post Nash equilibria of incomplete information games, and address this problem using "mediators." A mediator is a mechanism that does not have the power to enforce outcomes or to force participation; rather it only has the power to suggest outcomes on the basis of voluntary participation. We show that despite these restrictions mediators can implement equilibria of complete information games in settings of incomplete information assuming only that the game is large – there are a large number of players, and any player's action affects any other player's payoff by at most a small amount. Our result follows from a novel application of differential privacy.

■ WB15

15- Chartiers

Stationarity Conditions, Algorithms and Applications for PDE Constrained Optimization with Time Dependent Processes

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Nikolai Strogies, Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Berlin, Germany, strogies@math.hu-berlin.de

Co-Chair: Michael HintermüllerProf., Humboldt-Universitaet zu Berlin, Room 2.426 (House 2, 4th floor), Rudower Chaussee 25, Berlin, 12489, Germany, hint@math.hu-berlin.de

1 - Second-order Analysis for Optimal Control of the Schrödinger Equation

Axel Kroener, INRIA Saclay and CMAP, Ecole Polytechnique, Route de Saclay, 91128 Palaiseau Cedex, Palaiseau Cedex, France, axel.kroener@inria.fr, Maria Soledad Aronna, Frédéric Bonnans

In this talk we present second order necessary and sufficient optimality conditions for a bilinear optimal control problem governed by the Schrˆdinger equation with pointwise constraints on the control. The problem describes a quantum particle in a given potential subject to an electric field which represents the control. Second order necessary and sufficient optimality conditions are derived following ideas developed originally in the context of ordinary differential equations using the Goh transformation.

2 - A Priori Error Estimates for Nonstationary Optimal Control Problems with Gradient State Constraints

Francesco Ludovici, Universitaet Hamburg, Bundestrasse 55, Hamburg, Germany, francesco.ludovici@uni-hamburg.de, Ira Neitzel, Winnifried Wollner

In this talk we consider semilinear parabolic optimal control problems subject to inequality constraints on the gradient of the state variable. Our main focus will be on pointwise in time and averaged in space gradient state constraints. Making use of the discontinuous Galerkin method for the time discretization and of standard finite elements for the space discretization, we derive convergence rates as temporal and spatial mesh size tends to zero.

3 - Fast Solvers for Time-dependent PDE-constrained Optimization

John Pearson, EPSRC Fellow, University of Kent, Kent, United Kingdom, J.W.Pearson@kent.ac.uk

PDE-constrained optimization problems, especially those of time-dependent form, have numerous applications across mathematics and science more widely. In this talk we discuss the fast iterative solution of the huge-scale matrix systems that arise from finite element discretizations of these problems. Using the saddle point structure of the matrices involved, we are able to construct powerful preconditioners using effective approximations of the (1,1)-block and Schur complement. We consider a number of application areas, including the optimal control of fluid flow, pattern formation processes within mathematical biology, and models involving fractional differential equations.

■ WB16

16- Sterlings 1

Advances in Integer Programming V

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - The Impact of Linear Programming on the Performance of Branch-and-Cut based MIP Solvers

Matthias Miltenberger, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, miltenberger@zib.de, Thorsten Koch

A major part of the total running time of a branch-and-cut based MIP solver is spent solving LP relaxations. Therefore, one would expect the performance of the underlying LP solver to greatly influence the performance of the MIP solver. Surprisingly, this is often not the case. The solver framework SCIP allows to plug in various LP solvers, including SoPlex, XPRESS, CPLEX, and Gurobi. Using this setup we analyze the behavior and try to answer the question why the performance difference between the LP solvers does not necessarily translate to the MIP solver.

2 - Integer Programming by Projection

H. Paul Williams, Emeritus Professor of Operational Research, London School of Economics, Retired, Trencrom House, Cheriton Close, Winchester, Ha, SO22 5HN, United Kingdom, h.p.williams@lse.ac.uk, John Hooker

A method of solving (M)IPs by Projection is described. Projecting out variables from an IP results in a finite disjunction of polytopes.The resulting disjunction can be represented as the solution set of linear congruences in variables with bounded domains.Elimination of the integer variables can be accomplished by making use of the Generalised Chinese Remainder Theorem.The method leads to Branch-and-Bound and Cutting Plane procedures which are bounded by the number of variables in the model. The elimination procedure leads to a Value Function in which Shadow Prices are represented by Step Functions which are eventually Shift-Periodic. It also gives 'average' Shadow Prices.

3 - A New Algorithm for a Wide Class of Binary Bilevel Problems

Pierre-Louis Poirion, LIX, Ecole Polytechnique, Palaiseau, 91128, France, poirion@lix.polytechnique.fr, Sonia Toubaline, Claudia D'Ambrosio, Leo Liberti

We present a new algorithm to solve binary bilevel programs. At each step of the algorithm, we solve a binary linear slave program, check the feasibility for the master problem, and add a cut if the solution is not feasible. As an application, we show how this algorithm can be used to solve a binary bilevel model for real time control of medium voltage electrical networks.

■ WB17

17- Sterlings 2

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: Marina Andretta, University of São Paulo, Av. Trabalhador São-carlense, 400, São Carlos, SP, 13566590, Brazil, andretta@icmc.usp.br

1 - A Newton-Like Method for Distributed Optimization

Natasa Krejic, professor, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovica 4, Novi Sad, Serbia-Montenegro, natasak@uns.ac.rs, Dusan Jakovetic, Natasa Krklec Jerinkic, Dragana Bajovic

A connected network with n agents, each of which has access to† a local strongly convex function, is considered. The agents cooperate in minimizing the overall cost function. We propose a Newton-like method based on the particular structure of a penalty-like reformulation of the unconstrained problem. A second order information is incorporated into the distributive Newton step approximation. It is shown that the method converges linearly. Numerical results demonstrate a significant gain in terms of computational efficiency in comparison with the existing alternatives.

2 - Effective Methods for the Problem of Calculation of Matrix of Correspondences

Alexey Chernov, Moscow Institute of Physics and Technology, Institutskii pereulok, 9, Dolgoprudnyi, Russia, alexmipt@mail.ru, Alexander Gasnikov, Petro Stetsyuk

It is well known that the problem of calculation of the matrix of correspondences is reduced to the special type of entropy-linear programming (ELP) problem (A. Wilson). Recently there were obtained a few methods arXiv:1410.7719 for ELP with precise estimates of complexity. We compare these methods with Shor's r-algorithm, with well known Bregman's balancing method and with some others (Fang—Rajasekera—Tsão) on the example of the calculation of the matrix of correspondences. For the most of these methods there is no theoretical estimates of their global rate of convergence. Therefore, we present also encouraging results of numerical experiments.

3 - An Inner-Outer Nonlinear Programming Approach for Constrained Quadratic Matrix Model Updating

Marina Andretta, University of São Paulo, Av. Trabalhador São-carlense, 400, São Carlos, SP, 13566590, Brazil, andretta@icmc.usp.br, Ernesto G. Birgin, Marcos Raydan

Quadratic Finite Element Model Updating Problem (QFEMUP) concerns with updating a symmetric second-order finite element model so that it remains symmetric and the updated model reproduces a given set of desired eigenvalues and eigenvectors by replacing the corresponding ones from the original model. Taking advantage of the special structure of the constraint set, it is first shown that the QFEMUP can be formulated as a suitable constrained nonlinear programming problem. To avoid that spurious modes appear in the frequency range of interest in the updated model, additional constraints based on a quadratic Rayleigh quotient are dynamically included in the constraint set. Numerical experiments show that the algorithm works well in practice.

■ WB18

18- Sterlings 3

Topics in Optimization in Healthcare

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Andrew J. Schaefer, University of Pittsburgh, 3700 O'Hara Street, Benedum Hall 1048, Pittsburgh, PA, 15261-3048, United States of America, schaefer@ie.pitt.edu

1 - The Big Data Newsvendor: Practical Insights from Machine Learning

Gah-Yi Vahn, Assistant Professor, London Business School, Sussex Place, Regent's Park, London, United Kingdom, gvahn@london.edu, Cynthia Rudin

We investigate the newsvendor problem when one has n observations of p features related to the demand as well as historical demand data. We propose two approaches to finding the optimal order quantity in this new setting ó that of Machine Learning (ML) and Kernel Optimization (KO). We show that both solution approaches yield decisions that are algorithmically stable, and derive tight bounds on their performance. We apply the feature-based algorithms for nurse staffing problem in a hospital emergency room and find that the best KO and ML algorithms beat the best practice benchmark by 23% and 24% respectively in out-of-sample cost with statistical significance at the 5% level.

2 - Estimating Lipid Management Guidelines' Risk Value Of A Life Year On Treatment

Niraj Pandey, University at Buffalo, 342 Bell Hall, North Campus, Buffalo, NY, 14260, United States of America, npandey@buffalo.edu, Murat Kurt, Mark Karwan

Statins reduce the risk of heart attack and stroke with adverse side effects, but how to quantify these effects to help physicians make treatment decisions remains to be an open question. We gauge these adverse effects for patients with Type 2 diabetes from a central policy maker's point of view by formulating a dynamic decision model in which the objective is to minimize the risk of a first major cardiovascular event where time spent on treatment is penalized by a perceived risk increase. We seek penalty factors that make published lipid management guidelines as close as possible to optimal. We present computational results using clinical data and derive insights.

3 - Mitigating Information Asymmetry in Liver Allocation: A Stochastic Programming Approach

Andrew J. Schaefer, University of Pittsburgh, 3700 O'Hara Street, Benedum Hall 1048, Pittsburgh, PA, 15261-3048, United States of America, schaefer@ie.pitt.edu, Sepehr Nemati, Zeynep Icten, Lisa Maillart, Mark Roberts

Transplantation is the only treatment for end-stage liver disease, the twelfth-leading cause of death in the U.S. The U.S. liver allocation system induces information asymmetry, as patients are only required to update their health within certain prescribed time windows, which can lead to a misallocation of livers. Another concern is "update burden" – while requiring daily updates would eliminate the information asymmetry, it would be highly inconvenient for patients. We present a multi-objective stochastic program to simultaneously mitigate information asymmetry and update burden. We calibrate our model with clinical data and provide a set of Pareto-optimal health reporting requirements.

■ WB19

19- Ft. Pitt

Decision Diagrams in Optimization I

Cluster: Constraint Programming

Invited Session

Chair: John Hooker, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States of America, jh38@andrew.cmu.edu

1 - Scenario Bundling for Exact Multistage Stochastic Optimization

Utz-Uwe Haus, Cray Inc., Zufikon, 5621, Switzerland, uhaus@ethz.ch, Carla Michini, Marco Laumanns

We propose a generic method to reformulate multistage stochastic optimization problems as mixed-integer programs by bundling equivalent scenarios, avoiding scenario sampling. The approach makes use of binary decision diagrams to store a cover of the scenario space, and uses them to derive an inequality system for computing scenario probabilities conditioned on the lower-level decisions. As applications we discuss the pre-disaster network strengthening and network interdiction problems and showcase computational improvements over previous approaches.

2 - Solving the Pricing Problem in a Branch-and-Price Algorithm for Graph Coloring using ZDDs

David Morrison, Inverse Limit, 255 McDowell Lane Unit A, W Sacramento, CA, 95605, United States of America, drmorr@evokewonder.com, Edward Sewell, Sheldon Jacobson

Branch-and-price algorithms combine a branch-and-bound search with an exponentially-sized LP formulation that must be solved via column generation. Unfortunately, the standard branching rules used in branch-and-bound for integer programming interfere with the structure of the column generation routine; therefore, most such algorithms employ alternate branching rules to circumvent this difficulty. In this talk, we show how a zero-suppressed binary decision diagram (ZDD) can be used to solve the pricing problem in a branch-and-price algorithm for the graph coloring problem, even in the presence of constraints imposed by branching decisions. This approach can improve convergence of the column generation subroutine.

■ WB20

20- Smithfield

Fast Algorithms for Compressed Sensing and Matrix Completion

Cluster: Nonsmooth Optimization

Invited Session

Chair: Coralia Cartis, Associate Professor, University of Oxford, Mathematical Institute, Oxford, United Kingdom, coralia.cartis@maths.ox.ac.uk

1 - Parallel-l0: A Fully Parallel Algorithm for Combinatorial Compressed Sensing

Jared Tanner, Professor, Oxford University, Mathematical Institute, Oxford, United Kingdom, tanner@maths.ox.ac.uk, Rodrigo Mendoza-Smith

We consider the problem of solving for the sparsest solution of large underdetermined linear system of equations where the matrix is the adjacency matrix of an expander graph corresponding with at most d neighbours per node. We present a new combinatorial compressed sensing algorithm with provable recovery guarantees, fully parallel with computational runtime less than traditional compressed sensing algorithms, and able to recover sparse signals beyond l1-regularization.

2 - Model Expander Iterative Hard Thresholding

Bubacarr Bah, University of Texas, 2515 Speedway, Austin, TX, United States of America, bah@math.utexas.edu, Luca Baldassarre, Volkan Cevher

We present a linear time recovery algorithm with provable recovery guarantees for signals that belong to some general structured sparsity models, such as rooted connected trees and overlapping groups models, where the signals are encoded by sparse measurement matrices. The algorithm achieves relatively more accurate reconstruction from a much reduced sketch sizes, and it always returns a signal from the given sparsity model, which is useful to many applications since it allows to interpret the solution with respect to the chosen sparsity structure even in the presence of perturbations.

3 - Conjugate Gradient Iterative Hard Thresholding

Jeffrey D. Blanchard, Grinnell College, Grinnell College, Grinnell, IA, 50112-1690, United States of America, Blanchaj@Grinnell.edu

Conjugate Gradient Iterative Hard Thresholding (CGIHT) is a an effective algorithm for solving the L0 minimization problem in compressed and the low rank matrix completion problem. CGIHT combines low per iteration complexity (IHT, NIHT) with the accelerated asymptotic convergence rates of projection based algorithms (HTP, CoSaMP). In addition to competitive theoretical recovery guarantees, CGIHT is observed to recover sparse vectors and low rank matrices in less time than other algorithms.

■ WB21

21-Birmingham

Applications of Multiobjective Optimization

Cluster: Multi-Objective Optimization

Invited Session

Chair: Markus Hartikainen, Postdoctoral Researcher, University of Jyvaeskylae, P.O. Box 35, Jyvaeskylae, Finland, markus.hartikainen@jyu.fi

1 - Optimizing Marketing Activities in Banking System using Multi-Objective Optimization

Asaf Shupo, Manager, TD Bank Group, 77 King Street 10th fl, Toronto, Canada, asaf.shupo@td.com

In order to increase the volume of lending, retaining their customers, increasing long term profit, etc. banks organize promotion campaigns with different goals which in many cases conflicting each other. In marketing activities, marketers looking for customers that more likely generate high profit, high volume of lending, high respond rate, etc. Those objectives conflict each other, and the optimal solution should consider the tradeoff amongst the objectives. This current research presents an approach of using multi-objective optimization, finding optimal marketing strategy which optimizes at the same time the goals of a cash campaign: the average promotional rate, the total cash volume, and the total response rate of the campaign.

2 - Several Approaches for Solving the Multiobjective One-Dimensional Cutting Stock Problem

Angelo Aliano Filho, Master Degree, UNICAMP, Campinas, SP, Brazil, Campinas, SP, 13083-725, Brazil, angeloaliano@hotmail.com, Antonio Carlos Moretti, Margarida Vaz Pato

This work deals with the Multiobjective One-Dimensional Cutting Stock Problem (MODCSP). Due to its wide applicability in several fields, this problem is widely studied in Combinatorial Optimization. MODCSP has two objective functions that need to be minimized simultaneously, i.e., minimize the number of cutting patterns, and the number of setup machine. We developed several exact techniques of Multiobjective Optimization for obtain the optimal Pareto Front and we will present some ones in this conference.

3 - Forest Harvesting and Selling with Conflicting Objectives

Markus Hartikainen, Postdoctoral Researcher, University of Jyvaeskylae, P.O. Box 35, Jyvaeskylae, Finland, markus.hartikainen@jyu.fi

A decision problem concerning the harvesting of forest and selling the wood is considered based on conflicting objectives. Objectives considered include profit, sustainability and the amount of necessary renegotiation of previous deals with the wood buyers. Decision variables considered include the timings of the harvests and the amount of wood sold to various buyers. Pareto optimal solutions to the problem are found using multiobjective mixed-integer linear optimization and the SIMO program for forest management planning.

■ WB22

22- Heinz

Variational Analysis in Nonsmooth Optimization II

Cluster: Variational Analysis

Invited Session

Chair: Mau Nam Nguyen, Assistant Professor, Portland State University, 725 SW Harrison Street, Portland, OR, 97201, United States of America, mnn3@pdx.edu

1 - Second-Order Analysis of Piecewise Linear Functions and its Application to Lipschitzian Stability

Ebrahim Sarabi, Wayne State University, 695 Kirts Blvd, Apt 206, Troy, MI, 48084, United States of America, ebrahim.sarabi@wayne.edu, Boris Mordukhovich

We present second-order analysis of proper convex and piecewise linear functions. We first provide an efficient calculation of the prenormal cone to ∂f for a proper convex and piecewise linear f. Then we show how this allows us to find the second-order subdifferential for this class of functions entirely in terms of the initial data. Finally, if time permits, I will talk about the applications in sensitivity analysis.

2 - On the Convergence of the Proximal Forward-Backward Splitting Method with Linesearches

Yunier Bello Cruz, Universidade Federal de Goias, Campus Samambaia, UFG-IME Sala 219, Goiania, Brazil, yunier@impa.br, Nghia Tran

In this paper we focus on the convergence analysis of the proximal forward-backward splitting method for solving nonsmooth optimization problems in Hilbert spaces when the objective function is the sum of two convex functions. Assuming that one of the functions is Fr\'echet differentiable and using two new linesearches, the weak convergence is established without any Lipschitz continuity assumption on the gradient. Furthermore, we obtain many complexity results of cost values at the iterates when the stepsizes are bounded below by a positive constant. A fast version with linesearch is also provided.

3 - Generalized Differentiation and Characterizations for Differentiability of Infimal Convolutions

Mau Nam Nguyen, Assistant Professor, Portland State University, 725 SW Harrison Street, Portland, OR, 97201, United States of America, mnn3@pdx.edu

In this talk we present new results on generalized differentiation properties of the infimal convolution. This class of functions covers a large spectrum of nonsmooth functions well known in the literature. The subdifferential formulas obtained unify several known results and allow us to characterize the differentiability of the infimal convolution which plays an important role in variational analysis and optimization.

■ WB23

23- Allegheny

Complexity of Sparse Optimization in High Dimensions

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Alekh Agarwal, 641 Avenue of the Americas, 7th floor, New York, NY, 10023, United States of America, alekhagarwal@gmail.com

1 - Sparse Graph Estimation via Noncovex Optimization

Han Liu, Princeton University, Sherrerd Hall 224, ORFE, Princeton, NJ, 08544, United States of America, hanliu@princeton.edu

The graphical model has proven to be a useful abstraction in statistics and machine learning. The starting point is the graph of a distribution. While often the graph is assumed given, we are interested in estimating the graph from data. In this talk we present new statistical optimization methods for graph estimation. The performance of these methods is illustrated and compared on several real and simulated examples.

2 - On Iterative Hard Thresholding Methods for High-Dimensional M-Estimation

Prateek Jain, Microsoft Research India, #9 Lavelle Road, Bangalore, KA, 560001, India, prajain@microsoft.com, Ambuj Tewari, Purushottam Kar

The use of M-estimators in generalized linear regression models in high dimensional settings requires risk minimization with hard L0 constraints. Of the known methods, the class of projected gradient descent (also known as iterative hard thresholding (IHT)) methods is known to offer the fastest and most scalable solutions. However, the current state-of-the-art is only able to analyze these methods in extremely restrictive settings which do not hold in high dimensional statistical models. In this work we bridge this gap by providing the first analysis for IHT-style methods in the high dimensional statistical setting.

3 - Lower Bounds on the Performance of Polynomial-Time Algorithms for Sparse Linear Regression

Yuchen Zhang, University of California, Department of Computer Science, Berkeley, CA, 94720, United States of America, yuczhang@eecs.berkeley.edu, Michael I Jordan, Martin Wainwright

Under a standard assumption in complexity theory (NP not in P/poly), we demonstrate a gap between the minimax prediction risk for sparse linear regression that can be achieved by polynomial-time algorithms, and that achieved by optimal algorithms. In particular, when the design matrix is ill-conditioned, the minimax prediction loss achievable by polynomial-time algorithms can be substantially greater than that of an optimal algorithm. This result is the first known gap between polynomial and optimal algorithms for sparse linear regression, and does not depend on conjectures in average-case complexity.

■ WB24

24- Benedum

Decomposition Approaches in MINLP

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Giacomo Nannicini, Prof., SUTD, Singapore University of Technology and Design, 8 Somapah Road, Singapore, Singapore, nannicini@sutd.edu.sg

1 - A Decomposition-and-Reduce Approach for Stochastic Nonconvex Mixed-integer Nonlinear Programming

Xiang Li, Queen's University, 19 Division Street, Dupuis 403, Kingston, ON, K7L3N6, Canada, xiang.li@queensu.ca, Dan Li

We discuss an updated nonconvex generalized Benders decomposition (NGBD) method for solving stochastic nonconvex mixed-integer nonlinear programming (MINLP) problems. In this method, domain reduction techniques, such as bound contraction strategies, are systematically integrated into the NGBD procedure, leading to progressively improved convex relaxations and tightened variable bounds. The inclusion of domain reduction techniques not only reduces the number of NGBD iterations, but also speeds up the solution of nonconvex subproblems. Case study results show that, for some difficult stochastic nonconvex MINLPs, the updated NGBD method is faster than the standard NGBD method by over an order of magnitude.

2 - A Multiplicative Weights Update Algorithm for Quadratic MINLP

Luca Mencarelli, CNRS LIX, Ecole Polytechnique, Palaiseau, 91128, France, mencarelli@lix.polytechnique.fr, Leo Liberti, Youcef Sahraoui

We describe an adaptation of the Multiplicative Weights Update algorithm for Mixed-Integer Nonlinear Programming. This algorithm iteratively updates a distribution based on a gains/costs vector at the preceding iteration, samples decisions from the distribution in order to updates the gains/costs vector. Our adaptation relies on the concept of "pointwise reformulation", which depends from some parameters theta. The Multiplicative Weights Update algorithm is used to find good values for theta.

3 - Nonlinear Chance-Constrained Problems with Applications to Hydro Scheduling

Dimitri Thomopulos, University of Bologna, Viale Risorgimento 2, Bologna, Italy, dimitri.thomopulos@unibo.it, Andrea Lodi, Giacomo Nannicini, Enrico Malaguti

The midterm hydro scheduling problem is about optimizing the performance of a hydro network over a period of some months. This decision problem is affected by uncertainty on energy prices, demands and rainfalls, and we model it as a multi-stage nonlinear chance-constrained mathematical problem. At each stage we have to decide how much water to release from the reservoirs, and as a consequence, how much energy to produce. We present a Branch-and-Cut algorithm and a separation algorithm for the corresponding nonlinear scenario subproblems.

■ WB25

25- Board Room

Business Models for Integrating Demand Response in Electricity Markets

Cluster: Optimization in Energy Systems

Invited Session

Chair: Antony Papavasiliou, Assistant Professor, Catholic University of Louvain, Voie du Roman Pays 34, Office b.114, Louvain la Neuve, 1348, Belgium, anthony.papavasiliou@uclouvain.be

1 - A Business Model for Load Control Aggregation to Firm up Renewable Capacity

Shmuel Oren, Professor, University of California - Berkeley, IEOR Dept., Etcheverry Hall, Berkeley, CA, 94720, United States of America, oren@ieor.berkeley.edu, Clay Campaign, Kostas Margellos

We describe a business model for a retail electricity service aggregator that buys from its customers, options to limit total supply to their meters. The customers are responsible to meet the prescribed limits by managing the household energy use behind the meter. The aggregator can bundle the contracted curtailment options into wholesale DR offers or firm up wind resources offered into the wholesale energy markets. We formulate the overall aggregator problem optimizing the menu of contracts offered to retail customers along with the curtailment policy, the nameplate wind capacity matched up with the retail demand, and quantity of energy offered by the aggregator in the day ahead wholesale market as function of wholesale price.

2 - Models for Cooptimization of Demand and Reserve

Golbon Zakeri, University of Auckland, Private Bag 92019, Auckland, New Zealand, g.zakeri@auckland.ac.nz, Mahbubeh Habibian, Anthony Downward

We will provide a mixed integer program that co-optimizes the demand for a large consumer of electricity and the supply of reserve for this participant. We will discuss the properties of this model and present results.

3 - Priority Service Contracts for Residential Demand Response: Pricing, Aggregation and Dispatch

Antony Papavasiliou, Assistant Professor, Catholic University of Louvain, Voie du Roman Pays 34, Office b.114, Louvain la Neuve, 1348, Belgium, anthony.papavasiliou@uclouvain.be

We present an end-to-end priority service mechanism for mobilizing residential demand response. Consumers choose color designations for devices that correspond to reliability of service guarantees. Devices with specific colors are bundled into wholesale market energy and ancillary services bids. Accepted bids are translated to load control signals. An example illustrates the optimal design of the tariff and the dispatch of deferrable residential loads.

■ WB26

26- Forbes Room

Advances in Stochastic and Robust Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Sanjay Mehrotra, Professor, Northwestern University, IEMS Department, Evanston, IL, 60208, United States of America, mehrotra@northwestern.edu

1 - A Distributionally Robust Support Vector Machine Model and its Performance

Sanjay Mehrotra, Professor, Northwestern University, IEMS Department, Evanston, IL, 60208, United States of America, mehrotra@northwestern.edu

We propose a distributionally-robust framework for computing Support Vector Machines (DR-SVMs). We consider an ambiguity set for the population distribution based on the Kantorovich metric and present a distributionally-robust counterpart of the SVMs. Computational results on simulated and real data show that the DR-SVMs outperform the classical SVMs in terms of the Area Under Curve (AUC) measures when applied to small data.

2 - Experiences with First Order Methods in Some Stochastic Optimization Problems

Jorge Vera, Professor, Pontificia Universidad Catolica de Chile, Dept. Industrial and System Engineering, Vicuna Mackenna 4860, Santiago, 7820436, Chile, jvera@ing.puc.cl, Alfonso Lobos

First order methods have become increasingly important in recent years. Current literature shows promising applications in several areas, being stochastic optimization a very relevant one. In this work we show our experience with some first order methods, like the accelerated stochastic subgradient and Frank Wolfe methods, as well as a modified adaptive version of stochastic subgradient. We show results for some test instances as well as a two stage problem originating in a real industrial situation.

■ WB27

27- Duquesne Room

Quantum Communication Complexity and Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Joao Gouveia, University of Coimbra, Apartado 3008 EC Santa Cruz, Coimbra, 3001-501, Portugal, jgouveia@mat.uc.pt

1 - Sum of Squares Degree and Quantum Query Complexity

Troy Lee, Nanyang Technological University, 21 Nanyang Link, Singapore, Singapore, troyjlee@gmail.com, Ronald de Wolf, Jedrzej Kaniewski

The positive semidefinite rank is characterized by a one-way model of quantum communication complexity where the goal is to compute a function in expectation. We show this characterization holds for the two-way model of communication as well. Further, we study the analogous quantum query model of computing a function in expectation. We show that the complexity of a boolean function f in this model is characterized by the minimum d such f can be written as a sum of squares of degree d polynomials.

2 - Round Elimination in Exact Communication Complexity

Teresa Piovesan, PhD Candidate, CWI, Science Park 123, Amsterdam, Netherlands, piovesan@cwi.nl, Debbie Leung, Florian Speelman, Harry Buhrman, Jop Briet

We study two graph parameters, the chromatic number and the orthogonal rank, in the context of exact classical and quantum communication complexity. In particular, we consider a promise equality problem, where Alice and Bob must decide if their inputs are equal or not. For this, the chromatic number and the orthogonal rank (of a certain graph) characterise the one-round classical and one-round quantum communication complexity. While classically allowing multiple rounds does not give any advantage, we show an instance that exhibits an exponential gap between the one- and two-round quantum communication complexities.Thus the quantum communication complexity for every fixed number of rounds turns out to enjoy a much richer structure.

3 - Nonlocal Games and Conic Programming

Antonios Varvitsiotis, Research Fellow, Nanyang Technological University, Singapore and Centre for Quantum Technologies, National University of Singapore, Singapore, Singapore, avarvits@gmail.com, Jamie Sikora

A nonlocal game is a cooperative task between two players and a verifier: Each player is given a question by the verifier according to some joint probability distribution. The players respond to the verifier who consults a truth table dictating whether the players win or lose. The classical value of a game is the maximum winning probability using classical strategies and the quantum value is the maximum winning probability over all quantum strategies. We show that the classical and the quantum value of a nonlocal game can be formulated as linear conic programs over the completely positive and the completely positive semidefinite cone, respectively, and discuss the usefulness of these formulations.

■ WB28

28- Liberty Room

Advances in Solving QCQPs

Cluster: Global Optimization

Invited Session

Chair: Fatma Kilinc-Karzan, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, fkilinc@andrew.cmu.edu

1 - On Projected Cutting Surfaces for Mixed-Integer Quadratically Constrained Programs

Hongbo Dong, Assistant Professor, Washington State University, Neill 103, Pullman, WA, 99163, United States of America, hongbo.dong@wsu.edu

Convex relaxations with balanced strength and computational complexity are crucial for globally solving mixed-integer quadratically constrained programs. In this talk, we will focus on the idea of exploiting the strength of semidefinite relaxations (SDRs) by iteratively adding cutting surfaces to strengthen convex relaxations that are cheaper to solve than SDRs. We will extend our previous studies to more general instances of MIQCPs, and report our numerical results.

2 - A Generalized Trust Region Subproblem with Hollows and Non-Intersecting Linear Constraints

Boshi Yang, The University of Iowa, Department of Mathematics, Iowa City, IA, 52242, United States of America, boshi-yang@uiowa.edu, Kurt Anstreicher, Sam Burer

We study a generalized trust region subproblem in which a nonconvex quadratic function is minimized over unit ball and the intersection of n concave quadratic constraints and m non-intersecting linear constraints. Geometrically speaking, we first study the case when n small separate ellipsoids without intersecting boundaries are removed from the unit ball. We then take away m non-intersecting caps from the unit ball without touching the boundaries of the hollows inside. It is known that when n=0 or when n=1 and m=0, the problem has a tight Semidefinite Programming (SDP) relaxation. Our new result shows that the SDP relaxation is also tight for general n. and m .

3 - Convexity Analysis of Polynomials and Applications to Optimization

Krishnamurthy Dvijotham, Postdoctoral Fellow, California Institute of Technology, 68 N Michigan Ave, Apartment 2, Pasadena, CA, 91106, United States of America, dvij@cs.washington.edu, Venkat Chandrasekaran

We propose a general framework to analyze the domain of convexity of polynomials over the nonnegative orthant. Given a polytope P contained within the nonnegative orthant, we characterize a convex constraint on the coefficients of a polynomial so that the polynomial is provably convex over P, when reparameterized in terms of exponentials. For the special case of quadratic functions, we derive tighter characterizations of these conditions. We discuss the implications of these results to solving QCQPs and polynomial optimization problems over the non-negative orthant.

■ WB29

29- Commonwealth 1

Fast Algorithms for Convex Matrix Optimization Problems

Cluster: Nonsmooth Optimization

Invited Session

Chair: Defeng SunProf., National University of Singapore, Department of Mathematics, 10 Lower Kent Ridge Road, Singapore, Singapore, matsundf@nus.edu.sg

1 - Aug2QP: A Two-Phase Augmented Lagrangian Method for Large-Scale Convex Conic Quadratic Programming

Xudong Li, Research Assistant, National University of Singapore, Department of Mathematics, Block S17, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, matlixu@nus.edu.sg, Cui Ying, Defeng Sun, Kim-Chuan Toh

In this talk, we aim to solve high dimensional convex conic quadratic programming problems. To solve the targeted problems efficiently, we introduce a two-phase augmented Lagrangian method, with Phase I to generate a good initial point and Phase II to obtain an accurate solution fast. In Phase I, we first introduce a symmetric Gauss-Seidel (sGS) technique. This technique allows us to design a novel sGS based semi-proximal augmented Lagrangian method to find a solution of low to medium accuracy. Then, in Phase II, a proximal augmented Lagrangian algorithm, with the inner subproblems to be solved by combining an inexact accelerated proximal gradient (APG) method with the sGS technique, is proposed to obtain a more accurate solution.

2 - An Inexact Accelerated Block Coordinate Descent Method for Least Squares Semidefinite Programming

Defeng Sun, Prof., National University of Singapore, Department of Mathematics, 10 Lower Kent Ridge Road, Singapore, Singapore, matsundf@nus.edu.sg, Kim-Chuan Toh, Liuqin Yang

We consider least squares semidefinite programming (LSSDP) where the primal matrix variable must satisfy given linear equality and inequality constraints, and must also lie in the intersection of the cone of positive semidefinite matrices and a simple polyhedral set. We propose an inexact accelerated block coordinate descent (ABCD) method for solving the problem via its dual, which can be reformulated as a convex composite minimization problem whose objective is the sum of a coupled quadratic function involving four blocks of variables and two separable non-smooth functions involving only the first and second block, respectively.

3 - Low-rank Spectral Optimization

Michael Friedlander, University of California, Department of Mathematics, Davis, CA, 95616, United States of America, mpfriedlander@ucdavis.edu

Various applications in signal processing and machine learning give rise to highly structured spectral optimization problems characterized by low-rank solutions. Two examples include optimization problems from phase retrieval and matrix completion. I will describe how the particular structure of these problems allows for a special kind of duality framework that leads to computationally convenient formulations.

■ WB30

30- Commonwealth 2

Approximation and Online Algorithms VIII

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Yang Jiao, PhD Student, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, yangjiao@andrew.cmu.edu

1 - Designing Overlapping Publish-Subscribe Networks

Jennifer Iglesias, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, jiglesia@andrew.cmu.edu, R. Ravi, Ravi Sundarum, Rajmohan Rajaraman

The publish-subscribe network design problem is defined on a metric with given publisher and subscriber nodes and demands between them. The goal is to build a minimum total cost set of networks (one for each publisher, subscriber, each being a star or tree), where for each demand pair their networks overlap. I will present approximation algorithms for different types of demand sets and show the natural LP for this problem has an Omega(log log n) integerality gap.

2 - Approximation Schemes for the Container Selection Problem

Kanthi Sarpatwar, University of Maryland, College Park, 166 Westway, Apt T4, Greenbelt, MD, 20770, United States of America, kanthik@gmail.com, Viswanath Nagarajan, Baruch Schieber, Hadas Shachnai, Joel Wolf

The container selection problem is a special case of the non-metric k-median, naturally arising in cross platform scheduling. In the continuous variant, we are given a set C of input points in the d-dimensional real space, for some d>=2, and a budget k. An input point p can be assigned to a container point c only if c dominates p in every dimension. The assignment cost of p is equal to the L1-norm of point c. The goal is to find k container points in d-dimensional space such that the total assignment cost of all input points is minimized. The discrete variant of the problem has one key distinction ñ container points must be chosen from a given set F. We will discuss (bi) approximation schemes for both variants and some hardness results.

3 - Primal Dual Approximation Algorithm for Inventory Routing on the Line

Yang Jiao, PhD Student, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, yangjiao@andrew.cmu.edu

We consider the deterministic inventory routing problem over a discrete finite time horizon. Given clients on a metric, each with daily demands that must be delivered from a depot and holding costs over the planning horizon, an optimal solution selects a set of daily tours through a subset of clients to deliver all demands before they are due and minimizes the total holding and tour routing costs over the horizon. We give a constant factor primal dual approximation for inventory routing on the line metric.

Wednesday, 1:10pm - 2:40pm

■ WC01

01- Grand 1

Solvers for Mixed Integer Nonlinear Optimization Problems

Cluster: Implementations and Software

Invited Session

Chair: Pietro Belotti, Xpress Optimizer Team, FICO, Starley Way, Birmingham, United Kingdom, pietrobelotti@fico.com

1 - CCGO: A Fast Heuristic Global Optimizer

John Chinneck, Carleton University, Systems and Computer Engineering, 1125 Colonel By Drive, Ottawa, ON, K1S 5B6, Canada, chinneck@sce.carleton.ca, Mubashsharul Shafique

CCGO is a heuristic multi-start method for global optimization that is highly scalable and especially effective for nonconvex problems having multiple disconnected feasible regions. It finds good quality solutions quickly. The core components are: initial sampling, constraint consensus and clustering to identify feasible regions, direct search to improve clusters, and local solver launch. The algorithm is inherently concurrent. Empirical results show its effectiveness as compared to leading complete solvers and other multi-start codes.

2 - Non-Linear Modelling with Xpress Mosel and the New Variable Elimination Feature of Xpress-NLP

Livio Bertacco, FICO, Starley Way, Birmingham, B37 7GN, United Kingdom, liviobertacco@fico.com

This talk presents some recent enhancements to the FICO Xpress Mosel modelling language and non-linear solver. The new variable elimination feature of Xpress-NLP has led to large improvements in the modelling and solving of two pricing problems that use recursive formulae to predict demands. Another new feature of Mosel is the support for annotations which can be used to quickly define a user interface for FICO Optimization Modeler, or generate model documentation.

■ WC02

02- Grand 2

Progress in Energy Markets Optimization

Cluster: Optimization in Energy Systems

Invited Session

Chair: Miguel Anjos, Professor and Canada Research Chair, Polytechnique Montreal, C.P. 6079, Succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, miguel-f.anjos@polymtl.ca

1 - Look-ahead Scheduling of Energy, Reserves and Ramping under Uncertainty in a Two-Settlement Framework

Alberto Lamadrid, Lehigh University, 621 Taylor Street, Bethlehem, United States of America, ajlamadrid@lehigh.edu

This paper quantifies the technical and economic tradeoffs of an advanced scheduling model over generally accepted deterministic methods in use for the operation of the system. Our main contribution lies in the determination of benefits and costs between a systematic new model we are proposing, and policy rules in use by system operators, identifying key differences in provision of energy and ancillary services, their pricing and the overall security of the system. This paper builds on our previous work in this area, formulating a look-ahead optimization of the total net benefits, calculated as the expected benefits of electricity consumption net of the cost of energy and ancillary services for several periods.

2 - Electricity Forward Price Discovery for Structural Price Models

Boris Defourny, Assistant Professor, Lehigh University, 200 W Packer Ave, Bethlehem, PA, 18015, United States of America, defourny@lehigh.edu, Somayeh Moazeni

We first discuss a stochastic model of electricity spot prices that relies on a model of the supply stack capturing heat rates and fuel prices. We then propose an approach to discover electricity risk premiums and to construct electricity forward prices for long maturities, by leveraging the information in fuel forward curves.

3 - Optimization of a Distributed Generation Portfolio through Bilateral Contracts

François Gilbert, Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, IL, United States of America, fgilbert@anl.gov, Miguel Anjos, Patrice Marcotte, Gilles Savard

We consider an energy aggregator linking distributed generators with the grid through a two-sided portfolio of bilateral contracts, positioned for the point-wise procurement of energy to the grid. The challenge raised by the coordination of disparate resources and the securing of obligations over long time periods is addressed through a two-time scale model, where robust short term operational decisions are based on long term resource usage incentives, obtained from a min-cost flow representation that embeds the full extent of all contract durations.

■ WC03

03- Grand 3

Advances in Combinatorial Optimization and Applications

Cluster: Combinatorial Optimization

Invited Session

Chair: Santanu Dey, Associate Professor, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, United States of America, santanu.dey@isye.gatech.edu

1 - A Polyhedral Study of Multilinear Programs with Box Constraints

Alberto Del Pia, Assistant Professor, University of WisconsinñMadison, Madison, United States of America, delpia@wisc.edu, Aida Khajavirad

We study the polyhedral convex hull of a mixed-integer set S defined by a collection of multilinear equations over the 0-1-cube. Such sets appear frequently in the factorable reformulation of mixed-integer nonlinear optimization problems. In particular, the set S represents the feasible region of a linearized unconstrained zero-one polynomial optimization problem. Our theoretical developments extend several well-known results from the Boolean quadric polytope and the cut polytope literature, paving a way for devising novel optimization algorithms for nonconvex problems containing multilinear subexpressions.

2 - Semi-Infinite Relaxations for a Dynamic Knapsack Problem with Stochastic Item Sizes

Alejandro Toriello, Georgia Tech University, atoriello@isye.gatech.edu

We consider a knapsack problem in which item sizes are stochastic and realized after an attempted insertion, and the decision maker chooses an item to insert dynamically based on remaining capacity. We derive relaxations of polynomial and pseudo-polynomial size based on different approximations of the value function, relate them to previous work and compare them theoretically and computationally.

3 - Strengthened Sparse Approximations for Polytopes

Marco Molinaro, Georgia Tech ISyE, marco.molinaro@isye.gatech.edu, Andres Iroume, Santanu Dey

Sparse cutting-planes are often the ones used in mixed-integer programing (MIP) solvers, since they help in solving the linear programs encountered during branch-&-bound more efficiently. Together with Dey and Wang, we have started exploring the strength of sparse cuts, namely how well they can approximate the integer hull. In this talk I will present new analyzes of the strength of sparse cuts under more refined measures that attempt to better capture the situation encountered in integer programming.

■ WC04

04- Grand 4

Semidefinite Programming and Polynomial Optimization II

Cluster: Conic Programming

Invited Session

Chair: Cordian Riener, Aalto University, Aalto, Helsinki, Finland, Cordian.Riener@aalto.fi

1 - Polyhedral Approximation of the Completely Positive Semidefinite Cone

Sabine Burgdorf, Doktor, Centrum Wiskunde & Informatica (CWI), Science Park 123, Amsterdam, Netherlands, burgdorf@cwi.nl, Teresa Piovesan, Monique Laurent

The completely positive semidefinite cone is a generalization of the completely positive cone: it consists of nxn symmetric matrices that admit a Gram representation by positive semidefinite matrices of any size. This cone is used by Laurent and Piovesan to model quantum graph parameters as conic optimization problems, and by Mancinska and Roberson to characterize the set of bipartite quantum correlations as projection of an affine section of it. We present a hierarchy of polyhedral cones which covers its interior. This will be used for computing some variant of the quantum chromatic number by way of a linear program.

2 - A Semidefinite Algorithm for Decomposing Completely Positive Matrices

Jiawang Nie, Associate Professor, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA, 92093, United States of America, njw@math.ucsd.edu

A real symmetric matrix C is completely positive if C = B * B^T for a nonnegative matrix B. The question of deciding whether a matrix is completely positive or not can be equivalently formulated as a truncated moment problem. We propose a semidefnite algorithm for solving the question. It is based on solving semidefinite programs with moment variables. If a matrix is completely positive, then we can get a decomposition for it; if it is not completely positive, then we can get a mathematical certificate for that.

■ WC05

05- Kings Garden 1

Numerical Methods for Nonlinear Optimization II

Cluster: Nonlinear Programming

Invited Session

Chair: Ya-xiang Yuan, Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Zhong Guan Cun Donglu 55, Haidian, Beijing, 100190, China, yyx@lsec.cc.ac.cn

1 - Quasi-Newton Multipoint and Interpolation Methods with Line Search for Solving Nonlinear Equations

Oleg Burdakov, Linköping University, Linköping, Sweden, oleg.burdakov@liu.se, Ahmad Kamandi

We consider multipoint and interpolation methods for solving systems of nonlinear equations. They approximate the Jacobian matrix using quasi-Newton updates. Due to their ability to more completely utilize the information gathered at the previous iterations about the Jacobian matrix, these methods are especially efficient in the case of expensive functions. Their local convergence is known to be superlinear. We apply a line search strategy to make them globally convergent and justify this theoretically. Results of numerical experiments are presented. They show that the considered methods are more efficient than Broyden's method globalized in the same way.

2 - An Adaptive Feasible Discretization Method for Semi-Infinite Programming

Shuxiong Wang, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, No.55, ZhongGuanCun DongLu, Beijing, China, Beijing, 100190, China, wsx@lsec.cc.ac.cn, Ya-xiang Yuan

We present a novel method to solve semi-infinite programming which guarantees that each iteration point is feasible for the original problem. The basic idea is to construct some proper upper bound functions of the constraint function to obtain the consistent inner approximate region with finitely many constraints. The adaptive subdivision algorithm is proposed to obtain a Karush-Kuhn-Tucker point of the original problem for the given tolerance. A refinement procedure is designed to ensure that the approximate regions are monotone. We prove that our algorithm terminates in finite iterations. Numerical experiment shows the performance of our algorithm .

3 - A Modified Self-Scaling Memoryless BFGS Method for Unconstrained Optimization

Cai-Xia Kou, Beijing University of Posts and Telecommunications (BUPT), No. 10, XiTuChengLu, BUPT, Peking,China, Beijing, China, koucx@lsec.cc.ac.cn, Yu-Hong Dai

Recently, based on self scaling memoryless BFGS (SSMLBFGS) method by Perry and Shanno, new conjugate gradient algorithms, called CG_DESCENT and CGOPT, have been proposed by Hager and Zhang (2005) and Dai and Kou (2010), respectively. It is somewhat surprising that the two cg methods perform more efficient than the SSMLBFGS method.We propose an efficient implementation of the SSMLBFGS method with some suitable modifications. It is shown that the directions satisfy the sufficient descent conditions.Global convergence analysis is made for convex and nonconvex functions,respectively. The numerical experiments in CUTEr indicate that the modified SSM-BFGS method yields a desirable improvement over the original SSMLBFGS method and CGOPT.

■ WC06

06- Kings Garden 2

Scalable Algorithms for Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Ilya Safro, Assistant Professor, Clemson University, 228 McAdams Hall, Clemson, SC, 29634, United States of America, isafro@clemson.edu

1 - Scalable Dense Subgraph Discovery

Charalampos Tsourakakis, Postdoctoral Fellow, Harvard University, 33 Oxford Street, Cambridge, MA, 02138, United States of America, babis@seas.harvard.edu

In this talk we present the following contributions. (1) We develop an algorithm that achieves time- and space-efficiency {\em simultaneously} for the densest subgraph problem (DSP) in dynamic graphs. It is the first of its kind for graph problems to the best of our knowledge [STOC'15]. (2) We present the k-clique DSP, a generalization of the DSP. We show exact and approximation algorithms. Experimental evaluation indicates that as we increase the value of k we are able to find large near-cliques [WWW'15]. We believe that our work is a significant advance in routines with rigorous theoretical guarantees for scalable extraction of large near-cliques from networks. Joint work with: S.Bhattacharya, M.Henzinger, D.Nanongkai

2 - Parallel Algorithms for Geometric Graph Problems

Grigory Yaroslavtsev, Postdoctoral Fellow, University of Pennsylvania, 2400 Chestnut St., Apt. 2910, Philadelphia, PA, 19103, United States of America, grigory@grigory.us, Aleksandar Nikolov, Alexandr Andoni, Krzysztof Onak

I will describe algorithms for geometric graph problems in the modern parallel models inspired by MapReduce. The talk will be self-contained, including an introduction into models capturing "MapReduce"-like systems. I will also give describe a few major open problems in the area. As an example, I will present an algorithm for the Minimum Spanning Tree (MST) problem in 2D. The algorithm takes constant number of rounds of communication and total space and communication proportional to the size of the data. The ideas behind the MST algorithm can be expressed within a general "Solve-and-Sketch" algorithmic framework. Besides MST it also applies to the approximate Earth-Mover Distance (EMD) and the transportation cost problem.

3 - Multiscale Methods for Network Generation and Response to Epidemics

Ilya Safro, Assistant Professor, Clemson University, 228 McAdams Hall, Clemson, SC, 29634, United States of America, isafro@clemson.edu

In many real-world problems, a big scale gap can be observed between micro- and macroscopic scales of the problem because of the difference in mathematical (engineering, social, biological, physical, etc.) models and/or laws at different scales. The main objective of the multiscale algorithms is to create a hierarchy of problems, each representing the original problem at different coarse scales with fewer degrees of freedom. We present multiscale approaches for two problems: optimal response to epidemics, and network generation. Both approaches are inspired by algebraic multigrid scheme reinforced by the algebraic distance connectivity strength.

■ WC07

07- Kings Garden 3

Constraint Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Jordi Castro, Prof., Universitat Politecnica de Catalunya, Dept. of Stats. and Operations Research, Barcelona, Spain, jordi.castro@upc.edu

1 - Recent Branching Improvements for Mixed Integer Programming in SCIP

Gerald Gamrath, Zuse Institute Berlin, Takustr. 7, Berlin, Germany, gamrath@zib.de

One of the essential components of a branch-and-bound based mixed integer linear programming (MIP) solver is the branching rule. We report on recent branching improvements developed within the academic MIP solver SCIP. This includes strong branching with domain propagation to improve strong branching predictions and the first branching rule on general disjunctions implemented within SCIP which branches on multi-aggregated variables. Furthermore, we present how dual degeneracy can be exploited by cloud branching to get more exact pseudo costs and how the reliability of pseudo costs can be evaluated by statistical means.

2 - (Pre-)Solving Non-Linear Pseudo-Boolean Optimization Problems

Michael Winkler, Gurobi GmbH, Takustr. 7, Berlin, 14195, Germany, winkler@gurobi.com

Pseudo-Boolean Optimization is a generalization of Binary Programming that also allows terms involving products of binary variables. We describe an Constraint Integer Programming(CIP) approach that can be advantageous compared to a standard Mixed Integer Programming formulation. Furthermore, we introduce specialized presolving techniques for non-linear constraints that can be used to shrink the problem or even to transform non-linear to linear problems. These techniques have been implemented within the CIP framework SCIP, which is used for computational results.

3 - Branch-and-Cut for Linear Programs with Overlapping SOS1 Constraints

Tobias Fischer, TU Darmstadt, Graduate School of Computational Engineering, Dolivostr. 15, Darmstadt, 64293, Germany, fischer@gsc.tu-darmstadt.de, Marc Pfetsch

SOS1 constraints require that at most one of a given set of variables is nonzero. In this talk, we develop a branch-and-cut approach for SOS1 constraints, including branching rules, primal heuristics and cutting planes. We focus on the case in which the SOS1 constraints overlap and algorithmically exploit the corresponding conflict graph. In a computational study, we evaluate our implementation and compare it to the solution of a big-M formulation.

■ WC08

08- Kings Garden 4

Combinatorial Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Chenglong Zou, McGill University, 845 Rue Sherbrooke O, Montreal, Canada, chenglong.zou@mail.mcgill.ca

1 - Multiflow Colouring Results

Chenglong Zou, McGill University, 845 Rue Sherbrooke O, Montreal, Canada, chenglong.zou@mail.mcgill.ca

Given a graph G and a set of routing demands H, we wish to color H such that every color class can be simultaneously routed. A lower bound on the coloring number can be calculated by comparing cuts, but it is not clear what the upper bound is. In this talk, we cover results on Okamura-Seymour graphs; for non-crossing demands a tight gap can be obtained, but in the general case the gap can be as bad as a factor of 3/2.

2 - Adaptive Telecommunication Network Operation with a Limited Number of Reconfigurations

Frank Pfeuffer, Zuse Institute Berlin, Takustrafle 7, Berlin, 14195, Germany, pfeuffer@zib.de, Axel Werner

To reduce energy consumption, telecommunication providers consider to adapt their core network dynamically to follow the daily traffic curve by changing the configuration of the hardware, while imposing constraints ensuring network stability. We consider the problem of finding a limited number of time intervals partitioning a finite time horizon and network configurations able to route all traffic in its associated interval. We present an algorithm iteratively computing hop-constrained shortest cycles in a certain weighted graph and refining the arc weights obtained as lower and upper bounds of a network design problem. On practical instances only a fraction of all possibilities have to be explored.

■ WC09

09- Kings Garden 5

Topics in Robust Optimization II

Cluster: Robust Optimization

Invited Session

Chair: Dick den Hertog, Tilburg University, P.O. Box 90153, Tilburg, Netherlands, D.denHertog@uvt.nl

1 - A Composite Risk Measure Framework for Decision Making under Uncertainty

Zizhuo Wang, University of Minnesota, 111 Church St SE, Minneapolis, MN, 55455, United States of America, zwang@umn.edu, Pengyu Qian, Zaiwen Wen

We present a unified framework for decision making under uncertainty. Our framework is based on the composite of two risk measures, where the inner risk measure accounts for the risk of decision given the exact distribution of uncertain model parameters, and the outer risk measure quantifies the risk that occurs when estimating the parameters of distribution. The framework generalizes several existing models, including stochastic programming, robust optimization, distributionally robust optimization, etc. Using this framework, we study a few new models which imply probabilistic guarantees for solutions and yield less conservative results. Numerical test on portfolio selection problem are shown to demonstrate the strength of our model.

2 - Continuity of Robust Optimization Problems

Philip Mar, University of Toronto, 5 King's College Road, Toronto, On, M5S 3G8, Canada, philip.mar@mail.utoronto.ca, Timothy Chan

We discuss the stability properties of robust optimization satisfying the strong Slater condition, with closed and convex uncertainty sets. We show, by way of results in Linear Semi-Infinite Optimization, that the optimal values of two robust optimization problems satisfying certain conditions are Lipschitz continuous with respect to the Hausdorff distance between their respective uncertainty sets. We also present implications for measuring a price of robustness and approximating robust optimization with complex uncertainty sets.

3 - A Functional Robust Newsvendor Model for Coordinating Pricing and Inventory Strategies

Jian Hu, University of Michigan, jianhu@umich.edu, Sanjay Mehrotra, Junxuan Li

We propose a functional robust newsvendor model considering the coordination of pricing and inventory decisions in an uncertain and instability market. Respecting to the uncertainty and instability highly challenging the precise assessment of price-demand curves, this model specifies an uncertainty set of nonparametric price-demand curves in cooperation with the least-squares model fitting technique, and seeks the best decisions against the worst case. We discuss the impact of the functional robustness and the wholesale price on the maximum profit that a retailer can earn, and show that the performance of this model exhibits the principles of marketing.

■ WC10

10- Kings Terrace

Robust/Risk-Aware Stochastic Optimization and Game Theory

Cluster: Stochastic Optimization

Invited Session

Chair: William Haskell, Assistant Professor, National University of Singapore, 1 Engineering Drive, Singapore, 117576, Singapore, wbhaskell@gmail.com

1 - Dynamic Linear Programming Games with Risk-Averse Players

Nelson Uhan, Assistant Professor, United States Naval Academy, Chauvenet Hall, Annapolis, MD, 21402, United States of America, uhan@usna.edu, Alejandro Toriello

We study dynamic linear programming games, a class of cooperative games in which the costs of cooperation are uncertain and evolve over time, and the players are risk averse. These games generalize the classic linear production game, and as a result, model a variety of cooperative settings. We focus on the strong sequential core (SSC) of these games — the set of allocations that distribute costs as they are incurred and are stable against coalitional defections at any point in time — and establish sufficient conditions for its emptiness and non-emptiness. Qualitatively, whereas the SSC is always non-empty when players are risk-neutral, our results indicate that cooperation among risk-averse players is much more difficult.

2 - Learning with Stochastic Dominance

William Haskell, Assistant Professor, National University of Singapore, 1 Engineering Drive, Singapore, 117576, Singapore, wbhaskell@gmail.com, George Shanthikumar, Max Shen

We incorporate risk aversion into data-driven decision-making making in two settings. In the first setting, 'statistical learning', we design a loss function that incorporates a continuum of risk preferences via stochastic dominance. Then, we show how to construct a policy that maps data to decisions that minimizes this loss function. In the second setting, we solve online optimization problems with stochastic dominance constraints. In online optimization, we create a model for sequential decision making where the random reward is evaluated in terms of stochastic dominance. We solve a stochastic dominance-constrained multi-armed bandit as a special case.

3 - SHARP: A Novel Human Behavior Model in Repeated Stackelberg Security Games

Debarun Kar, University of Southern California, 941 Bloom Walk, SAL 300, Los Angeles CA 90089, United States of America, dkar@usc.edu, Francesco Delle Fave, Fei Fang, Nicole Sintov, Milind Tambe

Recently, researchers have focused on modeling human behavior to protect against boundedly rational adversaries in repeated Stackelberg security games (SSGs). However, the existing models rely on sufficient data in the initial rounds and fail to address the adversaries' skewed perception of probability and adaptation to past actions, which is extremely detrimental to defender performance. This paper presents a novel model, SHARP, to overcome these limitations. We compare the models when tested against human subjects, llustrating the strengths and weaknesses of different models and showing the advantages of SHARP.

■ WC11

11- Brigade

Special Input Types

Cluster: Combinatorial Optimization

Invited Session

Chair: Joachim Schauer, University of Graz, Universitaetsstrasse 15, Graz, 8010, Austria, joachim.schauer@uni-graz.at

1 - The Quadratic Assignment Problem is Easy for Robinsonian Matrices

Matteo Seminaroti, CWI, Science Park 123, Amsterdam, 1098 XG, Netherlands, m.seminaroti@cwi.nl, Monique Laurent

Robinsonian matrices arise in the classical seriation problem and in many applications where unsorted similarity (or dissimilarity) information must be reordered. We show that the quadratic assignment problem QAP(A,B) can be solved in polynomial time when A and B are, respectively, Robinson similarity and dissimilarity matrices and one of A or B is a Toeplitz matrix. Furthermore, we present a new polynomial-time algorithm to recognize Robinsonian matrices based on unit interval graphs and Lex-BFS.

2 - Asymptotic Aspects of the Quadratic Knapsack Problem

Joachim Schauer, University of Graz, Universitaetsstrasse 15, Graz, 8010, Austria, joachim.schauer@uni-graz.at

We study subclasses of the quadratic knapsack problem, where the profits are independent and identically distributed random variables defined on the interval [0,1] and the knapsack capacity is proportional to the number of items. We show asymptotically the the ratio of the optimal solution and the objective value of a very easy heuristic almost surely tends to 1 as the size of the knapsack instance tends to infinity. As a consequence using randomly generated instances falling into this scheme seems to be inappropriate for studying the performance of heuristics and (to some sense) exact methods. However such instances are frequently used in the literature for this purpose.

■ WC12

12- Black Diamond

Stochastic Optimization and Decomposition Methods

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Fabian Bastin, Associate Professor, University of Montreal, DIRO, CP 6128 Succ. Centre-Ville, Montreal, QC, H3C 3J7, Canada, bastin@iro.umontreal.ca

1 - Forced and Natural Nestedness

David Morton, Professor of Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, Tech, Evanston, IL, 60208-3109, United States of America, david.morton@northwestern.edu

We consider two classes of combinatorial optimization problems in which we seek a family of nested solutions. For the first class, we formulate two types of two-stage stochastic integer programs to force the nested structure, given a probability distribution on the uncertain model parameters, e.g., resource availability. For the second class, we maximize a supermodular gain function subject to a single resource-availability constraint, and give conditions which lead naturally to nestedness of solutions at certain budget increments. A facility location problem, a graph clustering problem, and a chance-constrained model illustrate ideas.

2 - Adaptive Sampling Trust Region Optimization (ASTRO)

Sara Shashaani, sara.shashaani@gmail.com, Raghu Pasupathy

We develop derivative free algorithms for optimization contexts where the objective function is observable only through a stochastic simulation. The algorithms we develop follow the trust-region framework where a local model is constructed, used, and updated as the iterates evolve through the search space. The salient feature of our algorithms is the incorporation of adaptive sampling to keep the variance (statistical error) and the squared bias (model error) of the local model in lock step, in a bid to ensure optimal convergence rates. Such balancing is accomplished dynamically, through careful estimation of errors using function estimates at visited points. We will discuss convergence and efficiency.

3 - Mixed Recursive Logit Models for Route Choice Analysis

Fabian Bastin, Associate Professor, University of Montreal, DIRO, CP 6128 Succ. Centre-Ville, Montreal, QC, H3C 3J7, Canada, bastin@iro.umontreal.ca, Emma Frejinger, Tien Mai

Route choice models are popular to describe individual path choices in a transportation, but are often considered as expensive to estimate and can present challenges for prediction. We propose a route choice model that takes advantages from the mixed logit models without requiring sampling of paths and is straightforward to use for prediction. We design a decomposition method in order to deal with the complexity of the model estimation. Correlations in the network are modeled using the subnetwork components approach proposed by Frejinger and Bierlaire (2007). Numerical experiments are performed base on a real network with more than 3000 nodes and 7000 links.

■ WC13

13- Rivers

Conic Linear Optimizaton

Cluster: Conic Programming

Invited Session

Chair: Tamás Terlaky, Department Chair, Lehigh University, Industrial Engineering Dept., 200 West Packer Ave., Bethlehem, PA, 18015, United States of America, terlaky@Lehigh.edu

Co-Chair: Julio Goez, Postdoctoral Student, GERAD, Universite de Montreal Campus, Montreal, Canada, jgoez1@gmail.com

1 - Using Disjunctive Conic and Cylindrical Cuts in Solving Quantitative Asset Allocation Problems

Sertalp B. Cay, PhD Student, Lehigh University, Dept. Industrial and Systems Engineering, 200 W. Packer Avenue, Bethlehem, PA, 18015, United States of America, sec312@lehigh.edu, Tamas Terlaky, Julio Gòez

The novel methodology of disjunctive conic and cylindrical cuts (DCC) was developed recently to solve mixed integer second order cone optimization (MISOCO) problems. First steps are made in implementing this powerful methodology in a Branch-and-Conic-Cut software package. In this talk we demonstrate the usefulness of this novel methodology in solving asset allocation problems that are modeled as MISOCO. Preliminary numerical results show that DCCs have significant positive impact when solving sets of realistic problem instances.

2 - On Disjunctive Conic Cuts: When They Exist, When They Cut?

Mohammad Shahabsafa, PhD Student, Lehigh University, Dept. Industrial and Systems Engineering, 200 W. Packer Avenue, Bethlehem, PA, 18015, United States of America, mos313@lehigh.edu

The development of Disjunctive Conic Cuts (DCCs) for MISOCO problems has recently gained significant interest in the optimization community. Identification of cases when DCCs are not existing, or not useful, saves computational time. In this study, we explore cases where either the DCC methodology does not derive a DCC which is cutting off the feasible region, or a DCC does not exist. Among others, we show that reformulating a p-order cone with a set of second order cones and then deriving DCC for the resulting MISOCO does not cut off the feasible region of the reformulated problem, while deriving DCCs directly for p-order cone optimization problems seems to be impossible.

3 - A Polynomial Primal-Dual Affine Scaling Algorithm for Symmetric Conic Optimization

Ali Mohammad Nezhad, PhD Student, Lehigh University, Dept. Industrial and Systems Engineering, 200 W. Packer Avenue, Bethlehem, PA, 18015, United States of America, alm413@Lehigh.EDU, Tamas Terlaky

The primal-dual Dikin-type affine scaling method was originally proposed for linear optimization and then extended to semidefinite optimization. Here, we generalize the method to symmetric conic optimization using the notion of Euclidean Jordan algebras. The method starts with a feasible but not necessarily centered primal-dual solution and features simultaneously centering and reducing the duality gap. The method's iteration complexity bound is analogous to the semidefinite optimization case.

■ WC14

14- Traders

Theory of Games involving Networks, Uncertainty and Computations in Static Games

Cluster: Game Theory

Invited Session

Chair: Vikas Vikram Singh, Post-Doc, Université Paris Sud, Laboratoire de Recherche en Informatique, Bat 650 Ada Lovelace, Orsay, 91405, France, vikas.singh@lri.fr

1 - A Polynomial Time Algorithm for Rank-1 Two Player Games (Despite Disconnected Solutions)

Ruta Mehta, Georgia Institute of Technology, 266 Ferst Drive, KACB, Room 2111, Atlanta, GA, 30332, United States of America, rmehta@gatech.edu, Bharat Adsul, Jugal Garg, Milind Sohoni

A finite two-player game is represented by two matrices (A,B), one for each player. The rank of such a game is defined as rank(A+B). Finding Nash equilibrium (NE) in zero-sum games, i.e., rank 0, reduces to linear programming (von Neumann'28). We solve the open question of Kannan and Theobald (2005) of designing an efficient algorithm for rank-1 games, where the main difficulty is disconnected solution set. We circumvent this by moving to a space of rank-1 games which contains our game (A, B), and defining a quadratic program whose optimal solutions are NE of all games in this space. We then isolate the Nash equilibrium of (A, B) as the fixed point of a single variable function which can be found in polynomial time via a binary search.

2 - Rationing Problems in Bipartite Networks

Jay Sethuraman, Columbia University, 500 West 120th Street, 314 S.W. Mudd Building, New York, NY, 10027, United States of America, jay@ieor.columbia.edu

In the bipartite rationing problem, a set of agents share a single resource available in different types, each agent has a claim over only a subset of the resource-types, and these claims overlap arbitrarily. The goal is to divide fairly the various types of resource between the claimants. We consider generalizations of standard rationing methods to the network context, and characterize the solutions using compelling axioms used in the economics literature on rationing. I will focus on two standard requirements—-truthfulness and consistency—-and discuss ways of extending standard rationing methods to the network setting while satisfying these properties (Joint work with Moulin, Ilkilic, Bochet, Chandramouli).

3 - Existence of Nash Equilibrium for n-Player Games with Random Payoffs

Vikas Vikram Singh, Post-Doc, Université Paris Sud, Laboratoire de Recherche en Informatique, Bat 650 Ada Lovelace, Orsay, 91405, France, vikas.singh@lri.fr, Oualid Jouini, Abdel Lisser

We consider n-player static games where each player has finite number of actions. Unlike the extensively studied case in the literature where the payoffs of all players are deterministic, we consider the situation where the payoffs of each player are random variables and follow a multi-normal distribution. We show that there always exists a mixed strategy Nash equilibrium. For two player games, where one row of row player's payoff matrix and one column of column player's payoff matrix are independent normal random variables, we develop an optimization problem and show the one-to-one correspondence between a Nash equilibrium of the game and a global minimum of the optimization problem.

■ WC15

15- Chartiers

Optimization of Non-Smooth and Complementarity-Based Systems with PDE-Constraints II

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Thomas Surowiec, Humboldt-Universität zu Berlin, surowiec@math.hu-berlin.de

1 - Strong Optimality Conditions for Optimization Problems with VI Constraints of the 2nd Kind

Juan Carlos De los Reyes, MODEMAT, Quito, Ecuador, juan.delosreyes@epn.edu.ec, Christian Meyer

We investigate optimality conditions for optimization problems constrained by a class of variational inequalities of the second kind. Based on a nonsmooth primal-dual reformulation of the governing inequality, the differentiability of the solution map is studied. Directional differentiability is proved both for finite-dimensional problems and problems in function spaces, under suitable assumptions on the active set. A characterization of Bouligand and strong stationary points is obtained thereafter. Finally, based on the obtained first-order information, trust-region algorithms are proposed for the solution of the optimization problems.

2 - Instantaneous Control of an EWOD Model with Complementarity-based Contact Line Pinning

Harbir Antil, Assistant Professor, George Mason University, 4400 University Drive, MS: 3F2, Exploratory Hall, room 4201, Fairfax, VA, 22030, United States of America, hantil@gmu.edu

A time-discrete spatially-continuous electrowetting on dielectric (EWOD) model with contact line pinning is considered as the state system in an optimal control framework. The pinning model is based on a complementarity condition. The associated optimal control problem thus becomes a mathematical optimization problem with equilibrium constraints in function space. In addition to the physical variables describing velocity, pressure, and voltage, the solid-liquid-air interface, i.e., the contact line, arises as a geometric variable that evolves in time. Primal first-order optimality and dual stationarity conditions are derived, respectively, using techniques from non-smooth optimization and set-valued analysis for each time step.

3 - A Vanishing Viscosity Based Relaxation-Regularization Method for MPCC's with Hyperbolic Operators

Nikolai Strogies, Humboldt-Universitaet zu Berlin, Unter den Linden 6, 10099 Berlin, Berlin, Germany, strogies@math.hu-berlin.de

The existence of solutions to a minimization problem subject to complementarity constraints involving a non-stationary linear hyperbolic first order differential operator will be discussed for a certain class of objective functionals. Stationarity conditions will be derived using a vanishing viscosity regularization of the operator and a penalization-relaxation technique for the complementarity constraint. Further a solution algorithm will be presented. The theoretical results will be illustrated by numerical experiments using conforming finite elements.

■ WC16

16- Sterlings 1

Advances in Integer Programming VI

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - Proximity Benders: A Decomposition Heuristic for Stochastic Programming

Matteo Fischetti, Prof., University of Padua, via Gradenigo 6/A, Padova, PD, 35126, Italy, matteo.fischetti@unipd.it, Natashia Boland, Michele Monaci, Martin Savelsbergh

Stochastic Programming models are typically solved through Benders decomposition, a dual solution method where a sequence of infeasible (super-optimal) solutions are generated until a first feasible solution is eventually found and the method terminates. As convergence may require a very large computing time, the method is quite unsatisfactory from a heuristic point of view. Proximity search is a recently-proposed heuristic paradigm, producing a sequence of feasible solutions of improved value. In this paper we investigate the use of proximity search as a tactical tool to drive Benders decomposition, and computationally evaluate its performance as a heuristic on different classes of stochastic programming problems.

2 - TU Representation of Matrices

Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zürich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch, Rico Zenklusen, Robert Hildebrand, Joerg Bader

Call a matrix A to have a TU representation V,W if [V,W] is TU and there exists an integral matrix U such that A = V + U W. We connect the TU representation of matrix A to the number of integer variables that are required to represent the integer programming problem Ax <= b, x integral. For instance, every binary knapsack master problem in n variables has a TU representation that allows us to reformulate the problem as mixed integer optimization problem in only sqrt(n) integral variables.

3 - Relationships between Simple Intersection Cuts, L&P Cuts, and Generalized Intersection Cuts

Tamas Kis, Institute for Computer Science and Control, Kende utca 13-17, Budapest, 1111, Hungary, kis.tamas@sztaki.mta.hu, Egon Balas

We examine the connections between the classes of cuts in the title. We show that lift-and-project (L&P) cuts are equivalent to generalized intersection cuts (GICs) obtained from positive combinations of the complements of the inequalities of each term of the disjunction. Moreover, we give necessary and sufficient conditions for an L&P cut to be equivanet to a SIC. We also show that L&P cuts from more general disjunctions than a split may not be equivalent to any SIC, which is in strong contrast with L&P cuts from a split which are known to be equivalent to SICs from the corresponding strip. We also give a numerical example for a MIP and a L&P cut which is not valid for any corner polyhedron obtained from any basis of the LP relaxation.

■ WC17

17- Sterlings 2

Nonlinear Optimization Algorithms

Cluster: Nonlinear Programming

Invited Session

Chair: Daniel P. Robinson, 3400 N. Charles Street, Baltimore, MD, 21218, United States of America, daniel.p.robinson@gmail.com

1 - Handling Negative Curvature in Gradient Methods for Unconstrained and Bound Constrained Optimization

Wei Guo, Lehigh University, 200 W Packer Ave, Bethlehem, United States of America, weg411@lehigh.edu, Frank E. Curtis

A gradient-descent method is proposed for unconstrained and bound constrained nonlinear optimization. Emphasis is placed on techniques for computing appropriate step sizes when negative curvature is present. The method extends the well-known Barzilai Borwein "two-point step size" method, its variants and gradient projection methods for unconstrained and bound constrained optimization, respectively. Global convergence is guaranteed under mild assumptions. Numerical results are presented to illustrate the benefits of the method in the presence of negative curvature.

2 - A QP Solver for Nonconvex Bound-Constrained Problems (NC-BCQP)

Hassan Mohy-ud-Din, Postdoctoral Associate (Yale, March 2015-), Johns Hopkins University (2009-15), Yale University (2015-), New Haven, New Haven, CT, United States of America, mohyuddin.engineer@gmail.com, Rachael E. H. Tappenden, Daniel P. Robinson

We present an active-set algorithm for finding a local minimizer to NC-BCQP. Our algorithm extends ideas developed by Dostal and Schoberl that is based on the linear CG algorithm for (approximately) solving a linear system with a positive-definite coefficient matrix. This is achieved by making two key changes. First, we perform a line search along negative curvature directions when they are encountered in the linear CG iteration. Second, we use Lanczos iterations to compute approximations to leftmost eigen-pairs, which is needed to promote convergence to points satisfying certain second-order optimality conditions. We prove convergence guarantees for the proposed algorithm, as well as demonstrate its robustness and efficiency on NC-BCQP.

3 - Approximate Inverse Preconditioning Strategies based on Krylov-Subspace Methods

Giovanni Fasano, Assistant Professor, University Ca'Foscari of Venice, Department of Management, S. Giobbe, Cannaregio 873, Venice, VE, 30121, Italy, fasano@unive.it, Massimo Roma

We propose a class of preconditioners for symmetric linear systems and sequences of linear systems. Our preconditioners are specifically suited for large indefinite linear systems and may be obtained as by-product of Krylov-subspace solvers. Each preconditioner in our class is identified by setting the values of some parameters and possibly scaling matrices. We provide theoretical properties of our preconditioners, including a discussion on the relation with LMP preconditioners by Gratton et al. Several new numerical results are also included, and a natural extension to a Preconditioned Nonlinear Conjugate Gradient method is proposed, showing the versatility of our approach.

■ WC18

18- Sterlings 3

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Joe Naoum-Sawaya, IBM Research, Damastown Industrial Estate, Dublin 15, Ireland, jnaoumsa@uwaterloo.ca

1 - A Benders and Cut Procedure for Supply Chain Design Problem

Defeng Sun, Northeastern University, China, 300 Gooding Way Apt 302, Albany, CA, 94706, United States of America, cdfsun@gmail.com, Lixin Tang

A Benders and Cut procedure is investigated for the supply chain design problem, based on the integration of algorithms such as Branch & cut, Lagrangian relaxation and Benders decomposition.

2 - Robust Critical Node Selection by Benders Decomposition

Joe Naoum-Sawaya, IBM Research, Damastown Industrial Estate, Dublin 15, Ireland, jnaoumsa@uwaterloo.ca, Christoph Buchheim

The critical node selection problem (CNP) seeks to determine the nodes to delete in a graph to minimize the number of connected pairs in the resulting residual network. In several applications, the weights on the connections are either uncertain or hard to estimate so recently robust optimization approaches have been considered for CNP. In this presentation, we address very general uncertainty sets, only requiring a linear optimization oracle for the set of potential scenarios. In particular, we can deal with discrete scenario based uncertainty, Gamma-uncertainty, and ellipsoidal uncertainty. For this general class of robust CNP, we propose an exact solution method based on Benders decomposition and provide extensive computational results.

3 - Heuristics for the Bin Packing Problem with Conflicts

Federico Pousa, Universidad de Buenos Aires, Ciudad Universitaria - Pabellon 1, Buenos Aires, Argentina, fedepousa@gmail.com, Isabel Mendez-Diaz, Paula Zabala

In the bin packing problem with conflicts, the aim is to assign items into the minimum number of bins subject to the fact that certain pairs of items cannot be assigned to the same bin. We propose an ILP formulation and several heuristics for the problem and we compare them to existing ones in the literature. The comparison shows that our approach outperforms the previous approximations in several benchmark instances.

■ WC19

19- Ft. Pitt

Decision Diagrams in Optimization II

Cluster: Constraint Programming

Invited Session

Chair: John Hooker, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States of America, jh38@andrew.cmu.edu

1 - Decision Diagrams for Efficient Inference and Optimization in Expressive Continuous Domains

Scott Sanner, Oregon State University, 1148 Kelley Engineering Center, Corvallis, OR, 97331, United States of America, ssanner@gmail.com

I will introduce an extension of the algebraic decision diagram (ADD) to continuous variables — termed the extended ADD (XADD) — to represent arbitrary piecewise functions and show how to define and efficiently compute elementary arithmetic operations, integrals, and maximization for various restrictions of these functions. Following this, I will briefly cover a wide range of applications where the XADD has yielded novel closed-form solutions: (a) probabilistic inference in hybrid graphical models, (b) parametric constrained optimization, and (c) continuous state, action, and observation sequential decision-making problems.

2 - Verifying Power Distribution Network with ZDDs

Takeru Inoue, NTT, Hikarinooka 1-1, Yokosuka, Japan, inoue.takeru@lab.ntt.co.jp, Norihito Yasuda, Yuji Takenobu, Shin-ichi Minato, Yasuhiro Hayashi, Shunsuke Kawano

Power distribution networks should be restored by reconfiguring switches automatically, given several feeders are interrupted in a severe accident. The network's design has to guarantee that it is restorable under any possible failure, but it is a computationally hard task to examine all possible failures. This paper proposes a novel ZDD method to find all the critical (unrestorable) line cuts with great efficiency to verify the network design. The method includes a fast screening algorithm based on hitting set enumeration, which is often used in data-mining. Thorough experiments reveal that the proposed method can find thousands of unrestorable cuts from the trillions of possible cuts in a large 432-Bus network.

3 - Toward Stochastic Optimization with Decision Diagrams

John Hooker, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States of America, jh38@andrew.cmu.edu

Relaxed decision diagrams have recently proved a useful alternative to the linear relaxation in the solution of combinatorial optimization problems. They allow problems with recursive formulations to be solved by branch-and-bound search within the relaxed diagram, without enumerating the state space. This talk presents underlying theory for extending this approach to stochastic optimal control. It defines the idea of a stochastic decision diagram and proposes a scheme for relaxing a diagram based on flow-path decomposition. This leads to a general concept of relaxation in stochastic dynamic programming.

■ WC20

20- Smithfield

Recent Advances in ADMM II

Cluster: Nonsmooth Optimization

Invited Session

Chair: Bingsheng He, Professor, Nanjing University, Department of Mathematics, Nanjing Unive, Nanjing, China, hebma@nju.edu.cn

1 - On the Proximal Alternating Direction Method of Multipliers

Caihua Chen, Dr., Nanjing University, 22 Hankou Road, Nanjing, China, chchen@nju.edu.cn

In this talk, we consider the use of the proximal alternating direction method of multipliers to solve linearly constrained separable programming problems. We first review and develop some convergence and complexity analysis results of the algorithm for convex programming. We also discuss some variants of PADMM, including the inertial PADMM and Bregaman ADMM, for convex programming and extend the algorithm to solve some specific nonconvex programming problems.

2 - The Direct Extension of ADMM for Three-Block Separable Convex Problems when one is Strongly Convex

Xingju Cai, Dr., Nanjing Normal University, caixingju@njnu.edu.cn, Xiaoming Yuan, Deren Han

ADMM is a benchmark for solving a two-block linearly constrained convex minimization model. It is known that the convergence is not guaranteed if the ADMM is directly extended to a three-block convex minimization model. While the original scheme of the direct extension of ADMM works for some applications and under some realistic conditions its convergence can be guaranteed. We give some results for the three-block case and show that when one of them is strongly convex, the direct extension of ADMM is convergent. Note that the strong convexity of one function does hold for many applications. We further estimate the worst-case convergence rate measured by the iteration complexity in both the ergodic and nonergodic senses.

■ WC21

21-Birmingham

Optimization and Variational Problems with Applications II

Cluster: Multi-Objective Optimization

Invited Session

Chair: Akhtar Khan, Associate Professor, Rochester Institute of Technology, Center for Applied and Comp. Math., School of Mathematical Sciences, Rochester, NY, 14623, United States of America, aaksma@rit.edu

Co-Chair: Christiane Tammer, Professor, Martin-Luther-University of Halle-Wittenberg, Institute of Mathematics, Halle-Salle, Germany, christiane.tammer@mathematik.uni-halle.de

Co-Chair: Baasansuren Jadamba, Rochester Institute of Technology, School of Mathematical Sciences, Rochester, NY, 14623, United States of America, bxjsma@rit.edu

1 - On Set-Valued Optimization Problems with Variable Ordering Structure

Christiane Tammer, Professor, Martin-Luther-University of Halle-Wittenberg, Institute of Mathematics, Halle-Salle, Germany, christiane.tammer@mathematik.uni-halle.de, Marius Durea, Radu Strugariu

We introduce and investigate an optimality concept for set-valued optimization problems with variable ordering structure. In our approach, the ordering structure is governed by a set-valued map acting between the same spaces as the objective multifunction. Necessary optimality conditions for the proposed problem are derived in terms of Bouligand and Mordukhovich generalized differentiation objects.

2 - Second-Order Sensitivity Analysis in Set-Valued Optimization

Douglas Ward, Professor, Miami University, Dept of Mathematics, Bachelor Hall, Oxford, OH, 45056, United States of America, wardde@miamioh.edu

In parametric nonlinear programming, second-order directional derivatives of the value function can be estimated in terms of the problem data. This paper explores how such estimates might be extended to a multiobjective, set-valued setting. We obtain estimates for the second-order contingent and adjacent derivatives of the epigraph of the “value multifunction” for a parametrized family of set-valued optimization problems.

3 - On Evolutionary and Elliptic Quasi Variational Inequalities

Akhtar Khan, Associate Professor, Rochester Institute of Technology, Center for Applied and Comp. Math., School of Mathematical Sciences, Rochester, NY, 14623, United States of America, aaksma@rit.edu

This talk will focus on some new existence and stability results for evolutionary and elliptic quasi-variational inequalities. This work is based on a joint work with Prof. Dumitru Motreanu.

■ WC22

22- Heinz

Contributions to Variational Analysis

Cluster: Variational Analysis

Invited Session

Chair: Hector Ramirez, Universidad de Chile, Beauchef 851, Piso 5, Santiago, Chile, hramirez@dim.uchile.cl

1 - Strong Convergent Tseng’s Algorithm for Solving Monotone Inclusions

Luis Briceño-Arias, Assistant Professor, Universidad Tècnica Federico Santa Marìa, Av. Vicuna Mackenna 3939, San Joaquin, Santiago, RM, 8940897, Chile, luis.briceno@usm.cl

The Tseng’s algorithm allows us to solve the problem of finding a zero of the sum of a set-valued maximally monotone operator and a single-valued monotone lipschitzian operator in a Hilbert space setting. The algorithm provided by Tseng generates a sequence converging weakly to a solution and strong convergence is guaranteed only under additional assumptions. In this talk we provide a strongly convergent version of Tseng’s method without additional assumptions. Inspired from the work of Haugauzaeau, we include additional projections to appropriate half spaces which guarantees the strong convergence of the iterates to the projection of the initial point onto the solution set. Some applications are examined.

2 - Sensitivity Analysis of Solution Maps to Parameterized Equilibria with Conic Constraints

Hector Ramirez, Universidad de Chile, Beauchef 851, Piso 5, Santiago, Chile, hramirez@dim.uchile.cl

We present new calculations of the graphical derivative, limiting coderivative and others generalized derivatives for the solution map to parameterized KKT systems associated with conic constraints. These computations are first derived provided the feasible set appearing in the KKT system is convex. They provide verifiable conditions for sensitivity properties (e.g., isolated calmness) of the corresponding solution map. We are able to extend the computation of the graphical derivative to the nonconvex case. The latter requires, however, an additional condition of geometric nature imposed on the considered cone.

3 - Large Sample Properties of an Optimization-Based Matching Estimator

Jorge Rivera, Universidad de Chile, DECON, Diagonal Paraguay 257, Santiago, Chile, jrivera@econ.uchile.cl, Roberto Cominetti, Juan Diaz

This paper studies the asymptotic properties of a new non-parametric matching estimator, which is based on the solution of a bi-level optimization problem. We show that this estimator of the average treatment effect attains the standard limit properties, with a rate of convergence of its conditional bias that improves the one obtained by Abadie & Imbens (2006) for the well-known nearest neighbor matching estimator.

■ WC23

23- Allegheny

Nonconvex Sparse Optimization

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Ting Kei Pong, The Hong Kong Polytechnic University, The Hong Kong Polytechnic University, Hong Kong, Hong Kong - PRC, tk.pong@polyu.edu.hk

1 - A Block Coordinate Descent Approach for Orthogonal Constrained Optimization Problems

Xin Liu, Associate Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, ICMSEC510, 55, Zhong Guan Cun East Road, Beijing, China, liuxin@lsec.cc.ac.cn, Ya-xiang Yuan, Xiaojun Chen

In this presentation, we introduce a special block coordinate descent framework for minimizing a nonconvex objective with orthogonal constraints. In this framework, each subproblem can be solved either exactly, when the computational cost is same as solving a trust-region subproblem, or inexactly, when sufficient reduction can be brought by taking a closed-form solution. Global convergence for this approach is established. Preliminary experiments illustrate that this new proposed approach performs well and is of great potential.

2 - Property of a Relaxation Scheme for Rank Constrained Optimization Problems

Xin Shen, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY, 12180, United States of America, shenx5@rpi.edu, John Mitchell

Recently rank constrained optimization problems have received increasing interest because of their wide application in many fields such as communication and signal processing. This class of problems has been considered computationally challenging because of its nonconvex nature. In this talk we focus on a mathematical program with semidefinite cone complementarity constraints (SDCMPCC) formulation of the class. We'll consider a relaxation scheme for the formulation and discuss its properties including constraint qualification, stationary conditions and local optimality.

3 - Splitting Methods for Nonconvex Feasibility Problems

Ting Kei Pong, The Hong Kong Polytechnic University, The Hong Kong Polytechnic University, Hong Kong, Hong Kong - PRC, tk.pong@polyu.edu.hk

We discuss the Douglas Rachford and the Peaceman Rachford splitting methods, which have been extensively studied in the convex scenario, for finding the intersection of a closed convex set and a possibly nonconvex closed set. We establish global convergence of the sequence generated to a stationary point of a certain optimization problem under mild assumptions on the sets and the stepsize. Our convergence analysis relies on a specially constructed new merit function. We also compare numerically the splitting methods with the alternating projection method on finding sparse vectors in an affine set. This is joint work with Guoyin Li.

■ WC24

24- Benedum

Mixed-Integer Nonlinear Optimal Control and Traffic I

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Sebastian Sager, Prof. Dr., Otto-von-Guericke Universitaet Magdeburg, Universitaetsplatz 2, Magdeburg, 39106, Germany, sager@ovgu.de

1 - Approximation Properties of Complementarity Constrained Problems in Mixed-integer Optimal Control

Christian Kirches, Junior Research Group Leader, TU Braunschweig / Heidelberg University, Im Neuenheimer Feld 368, Heidelberg, 69120, Germany, christian.kirches@iwr.uni-heidelberg.de

We take interest in solving mixed-integer optimal control problems (MIOCPs) that arise in process control and show significant potential for optimization. A framework based on partial outer convexification that results in an MPCC formulation has been proposed to solve MIOCPs efficiently. We show that this framework has an approximation property that results in feasibility and optimality certificates. After discretization, we may also efficiently compute approximate solutions. We propose a new sum-up rounding scheme required to maintain feasibility in the presence of complementarity constraints. We establish tight lower bounds for this approximation scheme that improve upon the best proven bounds for sum-up rounding.

2 - Continuous Stationarity Conditions for Hybrid System Model Predictive Control Problems

Andreas B. Hempel, ETH Zurich, Physikstrasse 3, Zurich, 8092, Switzerland, hempel@control.ee.ethz.ch, John Lygeros, Paul Goulart

Recent results in inverse parametric optimization enable us to represent continuous piecewise-affine (PWA) dynamical systems as optimizing processes. This alternative description makes use of a convex decomposition of the PWA dynamics and can be used to represent the system dynamics without resorting to binary variables to encode the different regions. We exploit this new representation to cast Model Predictive Control problems as mathematical programs with complementarity constraints. The structure inherited from the construction of the optimizing process description leads to strong stationarity conditions for the solutions to these optimization problems.

3 - Optimization of Vehicular Traffic at Traffic Light Intersections

Stephan Sorgatz, Volkswagen AG, Letterbox 011/1896, Wolfsburg, 38436, Germany, stephan.sorgatz@volkswagen.de, Sebastian Sager

Traffic light controlled intersections have a strong impact on traffic flow and emissions. High potential lies in influencing a driver's individual behaviour. We use C2X-Technology to gain knowledge about the signal phases and other relevant information in advance in order to plan and control a vehicle's velocity while approaching a traffic light. Furthermore we are interested in the idea of a junction without any regulation via traffic lights or right of way. We present a Mixed Integer Linear Problem and show first results and solving times.

■ WC25

25- Board Room

Approximate Dynamic Programming for Managing Energy Operations

Cluster: Optimization in Energy Systems

Invited Session

Chair: Selvaprabu Nadarajah, Assistant Professor of Operations Management, College of Business, University of Illinois at Chicago, 601 South Morgan Street, Chicago, IL, 60607, United States of America, selvan@uic.edu

1 - Adaptive Routing and Recharging Policies for Electric Vehicles

Irina Dolinskaya, Assistant Professor, McCormick School of Engineering and Applied Science, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208, United States of America, dolira@northwestern.edu, Diego Klabjan, Timothy Sweda

Recharging costs for an electric vehicle (EV), which increase as the battery's charge level increases, are fundamentally different than for conventional vehicles. Furthermore, the availability of charging stations along the way must be considered. We study the problem of finding an optimal routing and recharging policy for an EV in a grid network. We develop and analyze a variety of models depending on the amount and timing of information available to the EV driver while traveling.

2 - SDDP vs. ADP: Stochastic Optimization for Grid-Level Energy Storage

Warren Powell, Professor, Princeton University, ORFE, Princeton, NJ, 08544, United States of America, powell@princeton.edu, Tsvetan Asamov

In this work we consider the application of grid-level energy storage for the integration of renewable energy from off-shore wind farms into the power grid. We manage the set of storage devices in a coordinated fashion, and explore the application of different methodologies for approximating the solution of the resulting stochastic optimization problem. We perform computational experiments to analyze the performance of the system for various storage configurations and characteristics of the information state, and examine the sensitivity of the storage profile with respect to the size and efficiency of the batteries.

3 - Quasi-Convex Dynamic Programming Approximations

John Birge, University of Chicago, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States of America, jbirge@chicagobooth.edu

Typical dynamic energy problems involve states that evolve according to both controls (e.g., inventory) and exogenous variables (e.g., prices). The combination often leads to quasi-convex relationships. This talk will describe the use of dynamic programming approximations adapted for quasi-convex value functions.

■ WC26

26- Forbes Room

Computational Advances in Stochastic Programming

Cluster: Stochastic Optimization

Invited Session

Chair: Ignacio Grossmann, R. Dean University, Professor, Carnegie Mellon University, Doherty Hall, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, grossmann@cmu.edu

1 - Structure and Algorithms for Dominance Constraints Induced by Stochastic Programs with Recourse

Ruediger Schultz, University of Duisburg-Essen, Thea-Leymann-Strasse 9, Essen, Germany, ruediger.schultz@uni-due.de, Matthias Claus

Stochastic dominance constraints are flexible tools for bounding risk with respect to benchmark distributions. As with other stochastic programs underlying probability distributions often are subjective or coming from approximations. This raises questions of stability when approximating the distributions, as done in solution methods. We will discuss both algorithmic techniques relying on decomposition and recent results on metric regularity of constraint sets.

2 - A Cross-Decomposition Scheme for Two-Stage Mixed-Integer Stochastic Programming Problems

Pablo Garcia-Herreros, PhD Student, Carnegie Mellon University, Doherty Hall, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, pgarciah@andrew.cmu.edu, Sumit Mitra, Ignacio Grossmann

We describe a cross decomposition algorithm that combines Benders and Lagrangean decomposition for two-stage stochastic programs with mixed-integer first-stage and continuous second-stage decisions. The algorithm integrates primal and dual information with multi-cuts added to the Benders and Lagrangean master problems. The benefits are demonstrated with several instances of a facility location problem with disruptions. In the original formulation with weak LP relaxation, the cross-decomposition method outperforms multi-cut Benders decomposition. If the formulation is strengthened with tightening constraints, the performance of both decomposition methods improves but cross decomposition remains the fastest method for large-scale problems.

3 - An Algorithm for Multistage Mixed Nonlinear Convex Stochastic Problems

Eugenio Mijangos, University of the Basque Country (UPV/EHU), Sarriena s/n, Dept. de Mat. Aplic. y Est, Leioa, Spain, eugenio.mijangos@ehu.es

An algorithm for solving multistage mixed 0-1 stochastic problems with nonlinear convex objective function and convex constraints is presented. These problems have continuous and binary variables in each stage. The algorithm is based on the Branch-and-Fix Coordination method. As constraints are convex we approximate them by means of outer linear approximations. Each convex problem generated in the nodes of the trees of this method is solved by solving sequences of quadratic problems. It has been implemented in C++ with the help of Cplex 12.1 to solve quadratic approximations. Test problems have been randomly generated by a C++ code. Numerical experiments have been performed and its efficiency has been compared with that of BONMIN.

■ WC27

27- Duquesne Room

Network Design II

Cluster: Combinatorial Optimization

Invited Session

Chair: Jochen Könemann, University of Waterloo, 200 University Avenue West, Waterloo, ON, Canada, jochen@uwaterloo.ca

1 - Approximating Minimum Cost Connectivity Orientation and Augmentation

Laszlo Vegh, London School of Economics, Houghton street, London, WC2A 2AE, United Kingdom, L.Vegh@lse.ac.uk, Mohit Singh

We investigate problems addressing combined connectivity augmentation and orientations settings. We give a polynomial time 6-approximation algorithm for finding a minimum cost subgraph of an undirected graph G that admits an orientation covering a nonnegative crossing G-supermodular demand function. An important example is (k, l)-edge-connectivity. Our algorithm is based on a non-standard application of the iterative rounding method, requiring a new type of uncrossing on partitions and co-partitions. We also consider the problem setting when the cost of an edge can be different for the two possible orientations. We disprove an earlier conjecture by Khanna, Naor and Shepherd, showing a large integrality gap already in simple settings.

2 - Stochastic Budgeted Allocation with Traffic Spikes

Hossein Esfandiari, University of Maryland & Google Research, A.V. Williams Bldg, College Park, 20742, United States of America, esfandiari.hossein@gmail.com, Vahab Mirrokni, Nitish Korula

Motivated by Internet advertising applications, online allocation problems have been studied extensively in various adversarial and stochastic models. While the adversarial arrival models are too pessimistic, many of the stochastic arrival models do not realistically capture uncertainty in predictions. A significant cause for such uncertainty is the presence of unpredictable traffic spikes, often due to breaking news or similar events. In this work, we propose a robust online stochastic model that captures the nature of traffic spikes in online advertising, and design algorithms that adaptively reacts to inaccurate predictions. We provide provable almost tight bounds for our new algorithms in this framework.

3 - A 1.93-Approximation Algorithm for Submodular PCST on Bounded Treewidth Graphs

Wai Shing Fung, University of Waterloo, 200 University Avenue West, Waterloo, ON, Canada, wsfung@uwaterloo.ca, Takuro Fukunaga, Jochen Koenemann

Chekuri et al. and Bateni et al. showed that Prize-Collecting Steiner Tree(PCST) and Prize-Collecting Steiner Forest(PCSF) on planar graphs can be reduced to the same problems on bounded treewidth graphs and gave exact algorithms for PCST on these graphs, thus settling the hardness status of planar PCST. However, for PCSF on bounded treewidth graphs, we don't have an algorithm better than the 2.54-approximation for general graphs. Motivated by this, we consider the closely related Rooted PCSF problem and its generalization, the Submodular PCST problem. We introduced a new tree based LP formulation for Submodular PCST and gave an 1.93-approximation rounding algorithm for Submodular PCST on bounded treewidth graphs.

■ WC28

28- Liberty Room

Special Problems in Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Alexander Mitsos, Professor, Turmstrasse 46, Aachen, Germany, amitsos@alum.mit.edu

1 - A Bundle Algorithm for Solving Bilevel Optimization Problems

Susanne Franke, TU Bergakademie Freiberg, Nonnengasse 22, DG-09, Freiberg, 09596, Germany, susanne.franke@math.tu-freiberg.de, Stephan Dempe

Our basis is the optimistic bilevel programming problem. We apply the optimal value reformulation and assume that all functions are Lipschitz continuous. Using the concept of partial calmness allows us to formulate suitable constraint qualifications. In the talk, an already existing bundle algorithm for convex optimization problems is extended to the nonconvex case such that the method can be applied to our problem. A bundle is a set consisting of trial points, the respective objective function values and a subgradient at every point. The bundle is used for creating an approximation of the original function, and it is updated iteratively such that a sequence of trial points converging to the optimal solution of the problem is constructed.

2 - Convex Envelopes of Product-Separable Edge-Concave Functions

Yannis Guzman, Princeton University, A325 Engineering Quad, Princeton, NJ, United States of America, yguzman@princeton.edu, Christodoulos Floudas

We focus on a broad class of functions which have a vertex polyhedral convex envelope over a polytope domain. A quite general sufficient condition for class membership is to be edge-concave, i.e., to be concave along the edge directions of the domain. We present the explicit convex envelopes of edge-concave functions over a box which are product-separable, a condition which has been conjectured to apply to all non-concave edge-concave functions. The complexity of this diverse class of functions was reduced by defining conditions applicable to component univariate functions. The facets of the convex envelopes of every grouping are then determined explicitly by using the appropriate triangulation of the domain into simplices.

3 - Generalized Semi-Infinite and Bi-Level Programs to Ensure Transmission Electric Grid Security

Stephane Fliscounakis, Research Engineer, RTE/DES, 9 rue de la Porte de Buc, Versailles, France, stephane.fliscounakis@rte-france.com, Patrick Panciatici, Frédérique Verrier

This paper deals with day-ahead security management with respect to a set of contingencies taking into account uncertainties about the next day generation and load. In order to help the system operator, we want to check that no preventive action is required for the worst uncertainty pattern. Two types of optimization are used : discrete bi-level programs for simulation of contingencies, generalized semi-infinite programs for base case analysis.

■ WC29

29- Commonwealth 1

Algorithms for Monotone Variational Inequality and Structured Nonconvex Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Shiqian Ma, Assistant Professor, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, William M.W.Mong Engineering Building, Shatin, N.T., Hong Kong - PRC, sqma@cuhk.edu.hk

Co-Chair: Shuzhong Zhang, Professor, University of Minnesota, Department of Industrial and Systems Eng, Minneapolis, MN, 55455, United States of America, zhangs@umn.edu

1 - An Accelerated HPE-Type Algorithm for a Class of Composite Convex-Concave Saddle-Point Problems

Renato Monteiro, Professor, Georgia Tech, School of ISyE, Atlanta, GA, 30338, United States of America, renato.monteiro@isye.gatech.edu, Yunlong He

This talk discusses a new algorithm for solving a class of composite convex-concave saddle-point problems. The new algorithm is a special instance of the hybrid proximal extragradient framework in which a Nesterov's accelerated variant is used to approximately solve the prox subproblems. One of the advantages of the new method is that it works for any constant choice of proximal stepsize. Moreover, a suitable choice of the latter stepsize yields a method with the best known (accelerated inner) iteration complexity for the aforementioned class of saddle-point problems. In contrast to the smoothing technique, our accelerated method does not assume that feasible set is bounded due to its proximal point nature.

2 - Complete Dictionary Recovery over the Sphere

John Wright, Columbia University, 500 W. 120th Street, Room 1312, New York, NY, 10027, United States of America, johnwright@ee.columbia.edu

We consider the problem of recovering a complete dictionary A0, from Y = A0 X0 with Y in R^{n x p}. This recovery setting is central to the theoretical understanding of dictionary learning. We give the first efficient algorithm that provably recovers A0 when X0 has O(n) nonzeros per column, under suitable probability model for X0. Prior results provide recovery guarantees when X0 has only O(n^{1/2}) nonzeros per column. Our algorithm is based on nonconvex optimization with a spherical constraint, and hence is naturally phrased in the language of manifold optimization. Our proofs give a geometric characterization of the high-dimensional objective landscape, which shows that with high probability there are no spurious local minima.

3 - Iteration Bounds for Finding ϵ-Stationary Points for Structured Nonconvex Optimization

Bo Jiang, Assistant Professor, Shanghai University of Finance and Economics, Guoding Road 777, Shanghai, Sh, 200433, China, isyebojiang@163.com, Shuzhong Zhang

In this talk we study proximal conditional-gradient and proximal gradient-projection type algorithms for a block-structured constrained nonconvex optimization model, which arises naturally from tensor data analysis. We introduce a new notion of ϵ-stationarity, which is suitable for the structured problem under consideration. If the gradient of the nonconvex part of the objective f satisfies $\| \nabla f(x) - \nabla f(y)\|_q \le M \|x-y\|_p^\delta$ where $\delta=p/q$ with $1/p+1/q=1$, then we prove that the new algorithms have an overall iteration complexity bound of $O(1/\epsilon^q)$ in finding an ϵ-stationary solution. If f is concave then the iteration complexity reduces to $O(1/\epsilon)$.

■ WC30

30- Commonwealth 2

Approximation and Online Algorithms IX

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Jens Vygen, Professor, University of Bonn, Research Institute for Discrete Math., Lennestr. 2, Bonn, 53113, Germany, vygen@or.uni-bonn.de

1 - Approximation Algorithms for Regret-Bounded Vehicle Routing and Applications

Chaitanya Swamy, University of Waterloo, University of Waterloo, 200 University Avenue West, Waterloo, On, N2L 3G1, Canada, cswamy@uwaterloo.ca, Zachary Friggstad

We consider vehicle-routing problems (VRPs) that incorporate the notion of regret of a client, which is a measure of its waiting time relative to its shortest-path distance from the depot r. We obtain the first O(1)-approximation algorithm for additive-regret-bounded VRP, wherein we seek the fewest number of r-rooted paths that visit all nodes by time at most their shortest-path distance from r + a given regret bound. This also yields improved guarantees for distance-constrained VRP.

2 - Effective Resistance Reducing Flows, Spectrally Thin Trees and Asymmetric TSP

Shayan Oveis Gharan, University of Washington, CSE 636, Box 352350,, University of Washington, Seattle, WA, 94720, United States of America, shayan@cs.washington.edu, Nima Anari

We show that the integrality gap of the natural LP relaxation of the Asymmetric Traveling Salesman Problem (ATSP) is at most polyloglog(n). In other words, there is a polynomial time algorithm that approximates the value of the optimum tour within a factor of polyloglog(n). This is the first significant improvement over the classical O~(log n) approximation factor for ATSP. Our proof builds on recent developments in operator theory, in particular recent resolution of the Kadison Singer conjecture by Marcus, Spielman and Srivastava. In this talk, I will highlight the main ideas of our proof. This is a joint work with Nima Anari.

3 - Reassembling Trees for the Traveling Salesman

Jens Vygen, Professor, University of Bonn, Research Institute for Discrete Math., Lennestr. 2, Bonn, 53113, Germany, vygen@or.uni-bonn.de

Many recent approximation algorithms for variants of the traveling salesman problem exploit the fact that a solution of the natural linear programming relaxation can be written as convex combination of spanning trees. They randomly sample a tree from such a distribution and complete the tree to a tour at minimum cost. We argue that an additional step can help: reassembling the spanning trees before sampling. Exchanging two edges in a pair of spanning trees can improve their properties under certain conditions. We demonstrate the usefulness for the metric s-t-path TSP by devising a deterministic polynomial-time algorithm that improves on Sebo's previously best approximation ratio of 8/5.

Wednesday, 2:45pm - 4:15pm

■ WD01

01- Grand 1

Complementarity/Variational Inequality III

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Uday Shanbhag, Pennsylvania State University, 353 Leonhard Building, University Park, PA, 16802, United States of America, udaybag@psu.edu

1 - Vanishing Duality Gap in Non-Monotone Nearly Separable Variational Inequalities

Mengdi Wang, Princeton University, Sherrerd Hall ORFE, Princeton, NJ, 08544, United States of America, mengdiw@princeton.edu

Consider an n-dimensional VI that is not necessarily monotone. Assume that the objective function is "nearly separable": each component function is determined only by the corresponding component decision and a public variable which is a linear mapping of all decisions. An example is the equilibrium problem of a multi-person game subject to some public resource constraints. We show that an approximate solution to the nearly separable VI exists and can be computed efficiently. The approximation error can be estimated by the lack of monotonicity of the objective but is invariant under scaling the dimension n. This implies that the approximate solution is asymptotically optimal as the dimension n goes to infinity.

2 - A Unified Distributed Algorithm for Nonconvex Noncooperative Games

Meisam Razaviyayn, Stanford University, meisamr@stanford.edu, Jong Shi Pang

This talk introduces a unified framework for the design and analysis of distributed algorithms for computing first-order stationary solutions of non-cooperative games with non-differentiable player objective functions. The unified framework employs convex surrogate functions to handle non-smooth non-convex functions and covers many variants of distributed algorithms such as parallel versus sequential, scheduled versus randomized, and synchronous versus asynchronous transfer of information. We present the convergence analysis based on the contraction and potential approaches and discuss randomized extensions of the algorithms that require less coordination and hence are more suitable for big data problems.

3 - Misspecified Optimization and Variational Inequality Problems

Uday Shanbhag, Pennsylvania State University, 353 Leonhard Building, University Park, PA, 16802, United States of America, udaybag@psu.edu, Hao Jiang

We consider an imperfectly misspecified optimization/variational inequality problem and present recently developed iterative schemes for resolving this misspecification while solving the original problem in deterministic and stochastic regimes. Asymptotic statements and error bounds are provided.

■ WD02

02- Grand 2

Optmization in Energy Systems

Cluster: Optimization in Energy Systems
Invited Session

Chair: Konstantin Vandyshev, Delft University of Technology, Mekelweg 4, Delft, Netherlands, k.vandyshev@tudelft.nl

1 - Contingency Generation by Interior Point Methods for Optimal Power Flow

Andreas Grothey, University of Edinburgh, West Mains Road, Edinburgh, EH9 3JZ, United Kingdom, A.Grothey@ed.ac.uk, Nai-Yuan Chiang

Security Constrained Optimal Power Flow is an important problem for power systems operators. The structure of the problem resembles stochastic programming problems. Due to the presence of AC power flow constraints, the resulting problem is a large scale nonlinear programming problem. However only a small subset of the contingencies is active at the solution. We present an IPM based scheme that starts with a small base problem, generates likely active contingencies on-the-fly and integrates them into the algorithm using warmstarting techniques. The final problem solved by this scheme is significantly smaller than the full problem, resulting in speed gains. Numerical and theoretical results of our algorithm will be presented.

2 - Application of Semidefinite Programming to Secure Constrained Optimal Power Flow Problem

Konstantin Vandyshev, Delft University of Technology, Mekelweg 4, Delft, Netherlands, k.vandyshev@tudelft.nl, Dion Gijswijt, Karen Aardal

Recently, Semidefinite Programming (SDP) has been effectively applied to solve the Optimal Power Flow (OPF) problems. We extend this method to the Security Constrained OPF (SCOPF). Additional security constraints are added to the OPF formulation by applying the Current Injection method to predict the power flow along each line in the network. The SCOPF problem is then solved via SDP relaxation and the obtained results are compared with solutions from conventional optimization approaches.

3 - Tight Formulations for a Thermal Generator

Jim Ostrowski, University of Tennessee, 519 John Tickle Building, Knoxville, TN, 37996, United States of America, jostrows@utk.edu

We describe a polynomial sized convex hull for a thermal generator considering many types of constraints such as minimum up/downtime, startup/shutdown constraints, and ramping constraints. While polynomial, this formulation is very large and not computationally useful. However, it motivates a different formulation than has been used in the literature, one that can lead to significant computational speedups.

■ WD03

03- Grand 3

Discrete Convex Analysis I

Cluster: Combinatorial Optimization

Invited Session

Chair: Akiyoshi Shioura, Tokyo Institute of Technology, Oh-okayama, Meguro-ku, Tokyo, Japan, shioura.a.aa@m.titech.ac.jp

1 - On Polyhedral Approximation of L-convex and M-convex Functions

Kazuo Murota, University of Tokyo, Bunkyo-ku, Tokyo, Japan, murota@mist.i.u-tokyo.ac.jp

In discrete convex analysis, L-convexity and M-convexity are defined for functions in both discrete and continuous variables. Polyhedral L-/M-convex functions connect discrete and continuous versions. Here we show another role of polyhedral L-/M-convex functions: every closed L-/M-convex function in continuous variables can be approximated, uniformly on every compact set, by polyhedral L-/M-convex functions. The proof relies on L-M conjugacy under Legendre-Fenchel transformation.

2 - Some Specially Structured Assemble-to-Order Systems

Paul Zipkin, Professor, Duke University, Durham, NC, United States of America, paul.zipkin@duke.edu

Assemble-to-order systems are important in practice but challenging computationally. This paper combines some notions from combinatorial optimization, namely polymatroids and discrete convexity, to ease the computational burden significantly, for certain specially structured models. We point out that polymatroids have a concrete, intuitive interpretation in this context.

3 - Fixed-dimensional Stochastic Dynamic Programs: An Approximation Scheme and an Inventory Application

Wei Chen, The University of Texas at Dallas, 800 West Campbell Rd, SM30, Richardson, TX, 75080, United States of America, wxc103020@utdallas.edu, Milind Dawande, Ganesh Janakiraman

We study fixed-dimensional stochastic dynamic programs in a discrete setting over a finite horizon. Under the primary assumption that the cost-to-go functions are discrete L-natural convex, we propose a pseudo-polynomial time approximation scheme that solves this problem to within an arbitrary prespecified additive error. The main technique we develop for obtaining our scheme is approximation of a fixed-dimensional L-natural convex function on a bounded rectangular set, using only a selected number of points in its domain. Our approximation scheme is illustrated on a well-known problem in inventory theory, the single-product problem with lost sales and lead times.

■ WD04

04- Grand 4

Convex Conic Optimization: Models, Properties, and Algorithms II

Cluster: Conic Programming

Invited Session

Chair: Farid Alizadeh, Professor, Rutgers University, MSIS department, 100 Rockefallar, Room 5142, Piscataway, NJ, 08854, United States of America, alizadeh@rci.rutgers.edu

1 - DSOS and SDSOS: More Tractable Alternatives to Sum of Squares and Semidefinite Programming

Anirudha Majumbar, MIT, MIT 32-380 Vassar Street, Cambridge, MA, United States of America, anirudha@mit.edu, Amir Ali Ahmadi, Russ Tedrake

Sum of squares optimization has undoubtedly been a powerful addition to the theory of optimization in the past decade. Its reliance on relatively large-scale semidefinite programming, however, has seriously challenged its ability to scale in many practical applications. In this presentation, we introduce DSOS and SDSOS optimization as more tractable alternatives to sum of squares optimization that rely instead on LP and SOCP. We show that many of the theoretical guarantees of sum of squares optimization still go through for DSOS and SDSOS optimization. Furthermore, we show with numerical experiments from diverse application areas that we can handle problems at scales that are currently far beyond reach for sum of squares approaches.

2 - An Improved Bound for the Lyapunov Rank of a Proper Cone

Muddappa Gowda, Professor of Mathematics, University of Maryland Baltimore County, 1000 Hilltop Circle, Baltimore, MD, 21250, United States of America, gowda@umbc.edu, Michael Orlitzky

The Lyapunov rank (also called the bilinearity rank) of a proper cone in an n-dimensional real inner product space is the number of linearly independent Lyapunov-like linear transformations (also called bilinearity relations) needed to express its complementarity set. Such a set arises, for example, in conic optimization in the form of optimality conditions. In any symmetric cone (such as the nonnegative orthant or the semidefinite cone), the rank is at least the dimension of the ambient space and the complementarity set can be described by a square system of independent bilinear relations. With the goal of seeking such `perfect' cones, in this talk, we describe an improved bound for the Lyapunov rank.

3 - On a Generalized Second Order Cone

Roman Sznajder, Professor, Bowie State University, 14000 Jericho Park Road, Bowie, MD, 20715, United States of America, RSznajde@bowiestate.edu

In this paper, we study various properties of a generalized second order cone, considered as a multivariate version of topheavy cone with respect to arbitrary norm in a Euclidean space. Among other properties, we investigate the structure of Lyapunov-like transformations on such a cone and compute its Lyapunov rank.

WD05

05- Kings Garden 1

Choosing Optimal Software for Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Margaret Wright, Professor, Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, NY, 10012, United States of America, mhw@cs.nyu.edu

1 - Relative Minimization Profiles: A New Benchmarking Tool for Comparing General Optimization Methods

Tim Mitchell, Courant Institute of Mathematical Sciences, New York University, 251 Mercer St., New York, NY, 10012, United States of America, tim.mitchell@cims.nyu.edu, Michael L. Overton, Frank E. Curtis

We propose a new visualization tool called relative minimization profiles for comparing and benchmarking methods for general optimization problems, where there may be constraints and the objective and constraint functions may be nonsmooth and nonconvex. On a collection of heterogenous test problems, relative minimization profiles are able to elucidate the overall relative performances of multiple methods in terms of three metrics simultaneously: amount of objective minimization attained, feasibility error, and speed of progress.

2 - Computational Performance of Solution Techniques Applied to the ACOPF

Richard O'Neill, Federal Energy Regulatory Commission, richard.oneill@ferc.gov, Anya Castillo

We solve the Alternating Current Optimal Power Flow (ACOPF) using Conopt, Ipopt, Knitro, Minos, and Snopt. We report numerical results on various test problems in which we apply various mathematically equivalent ACOPF formulations. We run simulations on starting points that include starting from hot starts, randomized starting points, and the solution to a linearized model as an initialization. Our experimental results indicate a clear advantage to employing a multi-start strategy, which leverages parallel processing in order to solve the ACOPF on large-scale networks for time-sensitive applications.

3 - Choosing Optimal Software for Complicated Nonlinear Problems

Margaret Wright, Professor, Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, NY, 10012, United States of America, mhw@cs.nyu.edu

A large amount of information about nonlinear optimization software is available online—-even a Wikipedia article. The associated data come in multiple forms: detailed and extensive battery testing; sets of test problems in a variety of formats; published performance and data profiles; and lists of software in categories defined by problem features, methods, and accessibility. Even so, users seeking to solve complicated problems, especially from real-world applications in which derivatives are lacking, can benefit from additional information that is not easy to discern in the available resources. This talk will illustrate some forms of this added information and discuss strategies for obtaining it.

WD06

06- Kings Garden 2

Decision Making Algorithms for Robotic Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Sivakumar Rathinam, Asst. Professor, Texas A & M University, 3123 TAMU, Mechanical Engg, College Station, TX, 77843, United States of America, srathinam@tamu.edu

1 - Tight Lower Bounds for the Dubins Traveling Salesman Problem

Sivakumar Rathinam, Asst. Professor, Texas A & M University, 3123 TAMU, Mechanical Engg, College Station, TX, 77843, United States of America, srathinam@tamu.edu

The Dubins Traveling Salesman Problem (DTSP) has received significant interest over the last decade due to its occurrence in several civil and military surveillance applications. Currently, there is no algorithm that can find an optimal solution to the problem. In addition, relaxing the motion constraints and solving the resulting Euclidean TSP (ETSP) provides the only lower bound available for the problem. However, in many problem instances, this lower bound computed by solving the ETSP is far away from the cost of the best feasible solution available for the DTSP. This talk addresses this fundamental issue and presents the first systematic procedure with computational results for developing tight lower bounds for the DTSP.

2 - Exact Algorithms for Routing Multiple Unmanned Aerial Vehicles with Motion Constraints

Kaarthik Sundar, Texas A&M University, Dept. of Mechanical Engineering, College Station, United States of America, kaarthik01sundar@gmail.com

Unmanned aerial vehicles (UAVs) are being used in several monitoring applications to collect data from a set of targets. Routing a group of UAVs poses novel challenges because of the inherent non-holonomic motion constraints of the UAVs. In this talk, we will introduce exact algorithms for the minimum time motion planning and routing problem for a group of non-holonomic vehicles constrained to move along planar paths of bounded curvature. We will formulate the problem as a mixed integer linear program, study the facial structure of the polytope of feasible solutions and discuss algorithms to solve the the problem to optimality.

3 - State Aggregation based Approximate Dynamic Programming Methods and Bounds

Krishna Kalyanam, Research Scientist, InfoSciTex Corporation, AFRL/RQQA, Dayton, OH, United States of America, krishna.kalyanam@gmail.com, Meir Pachter, Swaroop Darbha

A common approximate dynamic programming method entails state partitioning and the use of linear programming, i.e., the state-space is partitioned and the optimal value function is approximated by a constant over each partition. By minimizing a positive cost function defined on the partitions, one can construct an upper bound for the optimal value function. We show that this approximate value function is independent of the positive cost function and that it is the least upper bound, given the partitions. A novel feature of this work is the derivation of a tractable lower bound via LP and the construction of a sub-optimal policy whose performance improves upon the lower bound.

WD07

07- Kings Garden 3

Advances in Integer Programming VII

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - Wide Split Disjunctions in MILP - Handling Holes in the Domains of Variables

Sven Wiese, University of Bologna, Viale Risorgimento 2, Bologna, 40136, Italy, sven.wiese@unibo.it, Andrea Tramontani, Andrea Lodi, Pierre Bonami

In MI(N)LP, unlike CP, we are able to express non-contiguous domains by auxiliary variables only. We explore the trade-off between using a black-box solver on such a MILP model on the one hand, and relaxing the constraints describing the arising holes in the domains and handling them algorithmically only, on the other. This is done by tailored branching and cutting planes derived from the wide split disjunctions arising from these holes.

2 - Solving Vertex Coloring Problems as Maximum Weighted Stable Set Problems

Enrico Malaguti, DEI - University of Bologna, Viale Risorgimento 2, Bologna, Italy, enrico.malaguti@unibo.it, Denis Cornaz, Fabio Furini

We solve coloring problems formulated as Maximum Weighted Stable Set Problems on an associated graph. We exploit the transformation proposed by Cornaz and Jost [Operations Research Letters 36 (2008)], where given a graph G, an auxiliary graph G' is constructed, such that the family of all stable sets of G' is in one-to-one correspondence with the family of all feasible colorings of G. We extend the transformation to some generalizations of the Vertex Coloring, and compare the method with the state-of-the art algorithms for the respective problems.

3 - A Theoretical Model of Branching Decisions in a Branch-and-Bound Algorithm

Pierre Le Bodic, H. Milton Stewart School of Industrial & Systems Engineering, Georgia Institute of Technology, 765 Ferst Drive, NW, Atlanta, GA, 30332-0205, United States of America, lebodic@gatech.edu, George Nemhauser

The purpose of this study is to theoretically model the branching decisions of a branch-and-bound algorithm from the dual standpoint. In this model, a variable is defined as a pair of dual gains, and a given dual gap must be closed. In this setting, we prove that minimizing the tree-size is #P-hard. We then consider a simpler model, and prove that there exists a closed-form formula for the tree-size. Early experiments yield promising results.

■ WD08

08- Kings Garden 4

Optimizing Donor Exchanges

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Joris Van de Klundert, Professor, Erasmus University Rotterdam, burg oudlaan 50, M5-29, rotterdam, 3000 DR, Netherlands, vandeklundert@bmg.eur.nl

1 - Robust Models for the Kidney Exchange Problem

Kristiaan Glorie, VU University Amsterdam, De Boelelaan 1081a, Amsterdam, Netherlands, km.glorie@vu.nl, Paul Bouman, Ana Viana, Margarida Carvalho, Miguel Constantino

Kidney exchanges aim to enable transplants between incompatible donor-patient pairs. A set of pairs must be chosen such that each selected patient can receive a kidney from a compatible donor from another pair in the set. The pairs are then notified and final compatibility tests are performed. We study the case in which if a test fails or a partaker withdraws, a new set of pairs may be selected. The new set should be as close as possible to the initial set so as to minimize the material and emotional alteration costs. Various recourse policies that determine the allowed post-matching actions are proposed. For each recourse policy a robust model is developed and techniques are presented to solve exactly the optimization problems in hand.

2 - Combining Human Value Judgments and Machine Learning to Match in Dynamic Environments

John Dickerson, PhD Candidate, Carnegie Mellon University, 9219 Gates-Hillman Center, Pittsburgh, PA, 15213, United States of America, dickerson@cs.cmu.edu, Tuomas Sandholm

Kidney exchange enables patients with kidney failure to swap willing but incompatible donors. Typically, a committee of experts directly creates a matching policy that tries to optimize some objective (e.g., "maximize matches"). We present a framework that takes as input a high-level objective determined by humans, then automatically learns based on data how to make this objective concrete and learns the means to accomplish this goal. We validate our method on real fielded exchange data.

■ WD09

09- Kings Garden 5

Inverse Optimization Theory and Applications

Cluster: Robust Optimization

Invited Session

Chair: Timothy Chan, University of Toronto, 5 King's College Rd., Toronto, Canada, tcychan@mie.utoronto.ca

1 - Inverse Optimization of Electricity Markets

John Birge, Jerry W. and Carol Lee Levin, Professors of Operations Management, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States of America, john.birge@chicagobooth.edu

Electricity markets provide both prices and quantities for energy and transmission, but many characteristics such as external commitments and specific physical features are not publicly observed. Since the price and quantities result from the primal and dual solutions of an optimization problem, the unknown characteristics can be revealed through inverse optimization. This talk will describe this process and an example with the Midcontinent ISO.

2 - Inverse Optimization in Countably Infinite Linear Programs

Archis Ghate, University of Washington, Box 352650, Seattle, WA, 98195, United States of America, archis@uw.edu

Given the costs and a feasible solution for a linear program, inverse optimization involves finding new costs that are close to the original ones and make the given solution optimal. We present an inverse optimization formulation for countably infinite linear programs (CILPs). Using the absolute sum metric, we reformulate this problem as another CILP. We propose a convergent algorithm, which solves a sequence of finite-dimensional LPs, to tackle this CILP. We apply this to non-stationary Markov decision processes.

3 - Goodness-of-Fit in Inverse Optimization

Timothy Chan, University of Toronto, 5 King's College Rd., Toronto, Canada, tcychan@mie.utoronto.ca, Taewoo Lee, Daria Terekhov

Inspired by goodness-of-fit in regression, we develop a measure that is comparable to R^2 for inverse optimization. When there is imperfect fit between model and data in inverse optimization, minimizing the error in the fit (e.g., duality gap) is one way to impute the desired model parameters. We begin with a general framework for inverse linear optimization that specializes into different formulations depending on the specific measure of error. For each, we develop a goodness-of-fit measure that retains many of the attractive properties of R^2: it takes on values in [0,1], is non-decreasing in the number of parameters to be imputed, and is maximized when applied to its corresponding model variant.

■ WD10

10- Kings Terrace

Nonlinear Financial Optimization

Cluster: Finance and Economics

Invited Session

Chair: Miguel Lejeune, Associate Professor, George Washington University, 2201 G St, NW, Funger Hall 406, Washington, DC, 20052, United States of America, mlejeune@gwu.edu

1 - A Robust Perspective on Transaction Costs in Portfolio Selection

Victor DeMiguel, Professor, London Business School, avmiguel@london.edu, Alba V. Olivares Nadal

We show that transaction costs can result in portfolios that are robust with respect to estimation error. Theoretically, we show that the portfolio optimization problem with transaction costs is equivalent to: (i) a robust portfolio optimization problem, (ii) a robust regression problem, and (iii) a Bayesian portfolio problem. Empirically, we propose a data-driven approach to portfolio selection. Specifically, we show how the transaction cost term can be calibrated to compute portfolios that are both efficient in terms of turnover, and robust with respect to estimation error. We demonstrate using five different empirical datasets that the proposed data-driven portfolios attain good out-of-sample performance.

2 - Risk-Budgeting Multi-Portfolio Optimization with Portfolio and Marginal Risk Constraints

Ran Ji, PhD Candidate, George Washington University, 2201 G St, NW, Funger Hall 415, Washington, DC, 20052, United States of America, jiran@gwu.edu, Miguel Lejeune

We propose a class of new stochastic risk budgeting multi-portfolio optimization models with portfolio and marginal risk constraints. The models permit the simultaneous and integrated optimization of multiple sub-portfolios in which a risk budget defined with a downside risk measure is assigned to each security and sub-portfolio. Each model includes a joint probabilistic constraint with multi-row random technology matrix. We expand a combinatorial modeling framework to represent the feasible set of the chance constraint as a set of mixed-integer linear inequalities. The efficiency and scalability of the method, numerical assessment on the performance of models, impact of parameters and diversification types are evaluated.

3 - Robust Investment Management with Uncertainty in Fund Managers' Asset Allocation

Aurelie Thiele, Lehigh University, 200 W Packer Ave, Bethlehem, PA, United States of America, aut204@lehigh.edu, Yang Dong

We consider a problem where an investment manager must allocate an available budget among a set of fund managers, whose asset allocations are not precisely known to the investment manager. We propose a robust framework that takes into account the uncertainty stemming from the fund managers' allocation, as well as the more traditional uncertainty due to uncertain asset returns, in the context of manager selection and portfolio management. We assume that only bounds on the fund managers' holdings are available. We propose two exact approaches (of different complexity) and an heuristic one to solve the problem efficiently, and provide numerical results.

■ WD11

11- Brigade

Computational Geometry

Cluster: Combinatorial Optimization

Invited Session

Chair: Tamon Stephen, Simon Fraser University, Department of Mathematics, 250-13450 102nd Ave., Surrey, BC, V3T 0A3, Canada, tamon@sfu.ca

1 - A Recursive Approach to Square Packing Problem

Azam Asl, NYU, 251 Mercer St, New York, Ne, 10012, United States of America, aa2821@nyu.edu

Consider the set of squares s = {s_0, s_1, ...,s_n-1}, in descending order and s_i < 1 for i=0,..,n-1 that would like to pack to the unit size square (bin). We present a recursive left-most_bottom-most algorithm which given that we can fit s_0 and s_1 into the bin (that is; iff s_0+s_1<=1), our packing algorithm will run for at least 2 iterations (k=2) and we prove to be able to cover at least 7/18 area of the bin. In general, if we have: s_0+s_1<=1, s_0+s_3+s_4<=1, ..., s_0+s_3+s_6+ ...+s_3p + s_(3p+1)<=1. Then k = p+2 and we prove to cover at least (1/2 - 1/(k+1)^2) area of the bin.

2 - An Efficient Local Search Algorithm for Nesting Problems of Rasterized Shapes

Shohei Murakami, Osaka University, 2-1 Yamadaoka, Suita, Osaka, Japan, syouhei.murakami@ist.osaka-u.ac.jp, Shunji Umetani, Yusuke Nakano, Hiroshi Morita

The raster models are simple to code and (approximately) represent non-convex and complex shapes, while they often need much memory and computational effort as their accuracy is improved. We develop an efficient algorithm to compute the overlap between a pair of shapes independent to the accuracy of the raster models. Based on this, we develop an efficient local search algorithm for the overlap minimization problem that minimizes the total amount of overlap between shapes.

3 - On the Diameter of Lattice Polytopes

George Manoussakis, PhD, University Paris 11, 39 Rue Paul Fort, Paris, 75014, France, gomanous@gmail.com, Antoine Deza

Finding a good bound on the maximal diameter D(d,n) of the vertex-edge graph of a polytope in terms of its dimension d and the number of its facets n is one of the basic open questions in polytope theory. The Hirsch conjecture, formulated in 1957 states that D(d,n) is at most n-d. While the conjecture was disproved by Santos in 2011, it is known to hold in small dimensions along with other specific pairs of d and n. However, the asymptotic behaviour of D(d,n) is not well understood: the best upper bound is quasi-polynomial. The behaviour of D(d,n) is not only a natural question of extremal discrete geometry, but is historically closely connected with the theory of the simplex method. We present older and recent results dealing with the diameter of lattice polytopes.

■ WD12

12- Black Diamond

Revenue Management and Dynamic Pricing

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Mikhail Nediak, Queen's University, 143 Union St., Kingston, ON, K7L3N6, Canada, mnediak@business.queensu.ca

1 - Robust Pricing for a Capacitated Resource

Shuyi Wang, Lehigh University, 200 W Packer Ave, Bethlehem, PA, United States of America, shw210@lehigh.edu, Aurelie Thiele

We investigate robust pricing strategies for capacitated resources in the presence of demand uncertainty. We consider uncertainty sets of the type proposed by Bertsimas and Bandi (2012) to incorporate moderate amounts of distributional information, provide theoretical insights and discuss extensions to dynamic pricing policies.

2 - Scalable Dynamic Bid Prices for Revenue Management in Continuous Time

Mikhail Nediak, Queen's University, 143 Union St., Kingston, ON, K7L3N6, Canada, mnediak@business.queensu.ca, Samuel Kirshner

We develop an approximate optimal control problem to produce time-dependent bid prices for network revenue management. The resulting bid prices are monotonic. Using sign-constrained splines we transform the problem into an approximate second-order cone program (ASOCP) where the number of variables depends solely on the number of resources and not on the length of the booking horizon. We highlight ASOCP's scalability by solving for dynamic bid prices on an industrial sized network in seconds.

3 - A Tractable Lagrangian Relaxation for General Discrete-Choice Network Revenue Management

Sumit Kunnumkal, Indian School of Business, Gachibowli, Hyderabad, India, Sumit_Kunnumkal@isb.edu, Kalyan Talluri

We propose a new Lagrangian relaxation method for the choice network revenue management problem. Our solution method applies to a general discrete-choice model of demand and remains tractable as long as the consideration sets of the different customer segments are small in size. We show that our solution method obtains an upper bound on the value function. We compare the quality of the upper bound obtained by the proposed method with existing benchmark methods both analytically and numerically.

■ WD13

13- Rivers

Cones of Completely Positive Matrices, Copositive Matrices and Related Topics

Cluster: Conic Programming

Invited Session

Chair: Gomatam Ravindran, Professor, SETS Campus, MGR Knowledge City, CIT campus, Taramani, Chennai, Taramani, 600113, India, gravi@hotmail.com

1 - Semidefinite and Completely Positive Relaxation of Polynomial Optimization by Using Symmetric Tensors

Xiaolong Kuang, Lehigh University, 14 Duh Drive Apartment 324,, Bethlehem, PA, 18015, United States of America, kuangxiaolong0731@gmail.com, Luis Zuluaga

We study relaxations of general polynomial optimization problems over the cone of positive semidefinite and completely positive tensors, which are natural extensions of the cones of positive semidefinite and completely positive matrices. Then we extend related results for quadratic polynomial optimization problems by characterizing the relationship between lagrangian, semidefinite, and comletely positive bounds for general polynomial optimization problems.

2 - Copositive Programming and Linear Complementarity Problems

Chandrashekaran Arumugasamy, Assistant Professor, Central University of Tamil Nadu, School of Mathematics and Computer Scien, Neelakudi Village, Kangalancheri Post, Thiruvarur, 610101, India, chandrashekaran@cutn.ac.in

In this talk we observe copositive programming as linear complementarity problems over the cone of copositive matrices. Linear complementarity problems over general cones have been studied in the literature and we shall review some of the known results. Then we discuss some new results in the theory of linear complementarity problems over the cone of copositive matrices.

3 - On Copositive and Codefinite Matrices

Kavita Bisht, Research Scholar, IIT Madras, Department of Mathematics, Chennai, 600036, India, kavitabishtiitm2512@gmail.com, Gomatam Ravindran, K.C. Sivakumar

In this paper we consider the concept of a copositive matrix introduced by Motzkin and obtain new results on copositive and strictly copositive matrices new results on the class of copositive matrices in the context of generalized inverses. We also extend a result relating copositive and codefinite matrices to singular matrices.We also present certain generalizations of some properties of self conditionally positive definite matrices and their connection to copositive matrices . Finally, we derive inheritance properties for the pseudo Schur complement for copositive and self conditionally positive definite matrices.

■ WD14

14- Traders

Behavioral Game Theory

Cluster: Game Theory

Invited Session

Chair: Albert Jiang, Trinity University, One Trinity Place, San Antonio, TX, 78212, United States of America, albertjiang@gmail.com

1 - Monotonic Maximin: A Robust Stackelberg Solution Against Boundedly Rational Followers

Albert Jiang, Trinity University, One Trinity Place, San Antonio, TX, 78212, United States of America, albertjiang@gmail.com, Milind Tambe, Thanh Nguyen, Ariel Procaccia

There has been recent interest in applying Stackelberg games to infrastructure security, in which a defender must protect targets from attack by an adaptive adversary. In real-world security settings the adversaries are humans and are thus boundedly rational. Most existing approaches for computing defender strategies against boundedly rational adversaries try to optimize against specific behavioral models of adversaries, and provide no quality guarantee when the estimated model is inaccurate. We propose a new solution concept, monotonic maximin, which provides guarantees against all adversary behavior models satisfying monotonicity, including all in the family of Regular Quantal Response functions.

2 - On Adversary Bounded Rationality in Green Security Domains: Payoff Uncertainty and Elicitation

Thanh Nguyen, University of Southern California, SAL, Los Angeles, United States of America, thanhhng@usc.edu, Milind Tambe, Noa Agmon, Manish Jain, Francesco Delle Fave, Amulya Yadav, Richard Van Deventer

Research on Stackelberg Security Games has recently shifted to green security domains, e.g., protecting wildlife from illegal poaching. Previous research on this topic has advocated the use of behavioral (bounded rationality) models of adversaries. This paper, for the first time, provides validation of these behavioral models based on real-world data from a wildlife park. The paper's next contribution is the first algorithm to handle payoff uncertainty in the presence of such behavioral models. Finally, given the availability of mobile sensors such as Unmanned Aerial Vehicles in green security domains, we introduce new payoff elicitation strategies to strategically reduce uncertainty over multiple targets at a time.

3 - Computation in Behavioural Game Theory using Gambit

Theodore Turocy, Professor of Economics, University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ, United Kingdom, T.Turocy@uea.ac.uk

I illustrate some of the facilities of Gambit: Software Tools for Game Theory (http://www.gambit-project.org) for analysing finite games using concepts from behavioural and statistical game theory. Using the Python extension, planned topics will include constructing game models programmatically, fitting quantal response equilibria and cognitive hierarchy models, and simulating trajectories of replicator dynamics, experience-weighted attraction, and other models of learning or adaptation.

■ WD16

16- Sterlings 1

Mathematical Programming in Data Science I

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Dolores Romero Morales, Professor in Operations Research, Copenhagen Business School, Porcelaenshaven 16 A, Copenhagen, Denmark, drm.eco@cbs.dk

1 - Increasing Sparsity in Support Vector Machines in the Presence of Categorical Data

Dolores Romero Morales, Professor in Operations Research, Copenhagen Business School, Porcelenshaven 16 A, Copenhagen, Denmark, drm.eco@cbs.dk, Emilio Carrizosa, Amaya Nogales Gomez

We propose the Cluster Support Vector Machines (CLSVM) methodology to increase the sparsity of the SVM classifier in the presence of categorical features. Four strategies for building the CLSVM classifier are presented based on solving: the original SVM formulation, a QCQP formulation, and an MIQP formulation as well as its continuous relaxation. We illustrate that our methodology achieves comparable accuracy to that of the SVM with original data but with a dramatic increase in sparsity.

2 - Similarity-Based Machine Learning in Large-Scale Data Sets

Philipp Baumann, University of California, Berkeley, Etcheverry Hall, Berkeley, IEOR Department, CA, 94720, United States of America, philipp.baumann@berkeley.edu, Dorit S. Hochbaum

Leading data mining algorithms require as input pairwise similarities between objects. This poses a challenge in terms of scalability as the number of pairwise similarities grows quadratically in the size of the data set. We address this challenge with a method called sparse computation that generates only relevant similarities. Sparse computation is used here in combination with support vector machines, the k-nearest neighbor algorithm and the supervised normalized cut algorithm to tackle large real-world classification problems. It turns out that the running time of these algorithms can be reduced significantly with minimal loss in accuracy.

3 - Data-Driven Risk-Averse Stochastic Optimization with Wasserstein Metric

Chaoyue Zhao, Assistant Professor, Oklahoma State University, 322 Engineering North, Stillwater, OK, 74078, United States of America, chaoyue.zhao@okstate.edu, Yongpei Guan

In this talk, we study the data-driven risk-averse stochastic optimization problem. Instead of assuming the distribution of random parameter is known, a series of historical data, drawn from the true distribution, are observed. Based on the obtained historical data, we construct the confidence set of the ambiguous distribution of the random parameters, and develop a risk-averse stochastic optimization framework to minimize the total expected cost under the worst-case distribution. We introduce the Wasserstein metric to construct the ?confidence set and by using this metric, we can successfully reformulate the risk-averse two-stage stochastic program to its tractable counterpart. Moreover, we perform convergence analysis to show that the risk-averseness of our proposed formulation vanishes as the amount of historical data grows to infinity, and accordingly, the optimal objective value converges to that of the traditional risk-neutral two-stage stochastic program. Finally, numerical experiments on facility location and stochastic unit commitment problems verify the effectiveness of our proposed solution approach.

■ WD17

17- Sterlings 2

Nonconvex, Non-Lipschitz, and Sparse Optimization II

Cluster: Nonlinear Programming

Invited Session

Chair: Xiaojun Chen, Professor, The Hong Kong Polytechnic University, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, xiaojun.chen@polyu.edu.hk

1 - A Comparison of Lipschitz and Non-Lipschitz Functions for Nonconvex Compressive Sensing

Rick Chartrand, Descartes Labs, Inc., 1350 Central Ave., Ste. 204, Los Alamos, NM, 87544, United States of America, rick@descarteslabs.com

That nonconvex functions can give better results for compressive sensing is well established. The best-known of these, the p-norms (or Lp quasinorms), are also non-Lipschitz. A drawback the p-norms have is that they lack closed-form proximal mappings (except for special values of p, like 1/2). This led to the introduction of functions constructed to have specified proximal mappings, yet be similar to p-norms. The biggest difference is that the new functions happen to be Lipschitz. Since these functions were introduced for reasons of computational efficiency, and not reconstruction performance, an unsettled question is whether they perform better than the p-norms. In this talk we will present results attempting to answer this question.

2 - SAA Regularized Methods for Multiproduct Price Optimization under Pure Characteristics Demand Models

Che-Lin Su, University of Chicago, 5807 S Woodlawn Ave, Chicago, IL, 60637, United States of America, csu1@chicagobooth.edu, Hailin Sun, Xiaojun Chen

Utility-based choice models are often used to provide an estimate of product demands, and when data on purchase decisions or market shares are available, to infer consumers' preferences over observed product characteristics. They also serve as a building block in modeling firms' price and assortment optimization problems. We consider a multi-product price optimization problem under the pure characteristics model. We use a sample average approximation (SAA) method to approximate the expected market share of products and the firm's profit. We apply a regularized method to compute a solution of the SAA problem and study the convergence of the SAA solutions when the sample size increases.

3 - Fast Approximate Solutions of High Dimensional Affine VIs and LCPs Using Random Projections

Ankur Kulkarni, Assistant Professor, Indian Institute of Technology Bombay, Powai, Mumbai, India, kulkarni.ankur@iitb.ac.in, Bharat Prabhakar

We present a method for dimensionality reduction of affine VIs and LCPs. Centered around the Johnson Lindenstrauss lemma, our method is a randomized algorithm that produces with high probability an approximate solution for the given AVI by solving a lower-dimensional AVI. This approximation can be used to hot start an exact algorithm. The lower-dimensional AVI is obtained by appropriately projecting the original AVI on a randomly chosen subspace. From the solution of the lower-dimensional AVI an approximate solution to the original AVI is recovered through an inexpensive process. Our numerical experiments validate that the algorithm provides a good approximation at low dimensions and substantial savings in time for an exact solution.

■ WD18

18- Sterlings 3

Optimization Computing and Analysis in Statistical Methods

Cluster: Nonlinear Programming

Invited Session

Chair: Shu Lu, Assistant Professor, University of North Carolina at Chapel Hill, 355 Hanes Hall, Cb#3260, UNC-Chapel Hill, Chapel Hill, NC, 27599, United States of America, shulu@email.unc.edu

1 - Optimization of Some Recent Statistical Methods

Lingsong Zhang, Assistant Professor of Statistics, Purdue University, Department of Statistics, Purdue University, 150 N University St., West Lafayette, IN, 47907, United States of America, lingsong@purdue.edu

Optimization is an integrated part in statistical theory and methodology. In this paper, we discuss several important new methodology developments in statistics, and address important optimization aspects in optimization, which include linear programming, conic programming, etc. In addition, some computational considerations on extending these approaches to big data context will be addressed as well.

2 - Convex Optimization in Synthesis of Stationary Gaussian Fields

Stefanos Kechagias, SAS Institute, 100 SAS Campus Dr, Cary, NC, 27513, United States of America, stefanoskeh@gmail.com, Vladas Pipiras, Hannes Helgason

Stationary Gaussian random fields are used as models in a range of applications such as image analysis or geostatistics. One of the most effective and exact methods to synthesize such fields is based on the so-called circulant matrix embedding (CME). But the standard version of the method works only under suitable assumptions, which are well-known to fail for many practical covariance structures of interest. In this talk, I will present a novel methodology, which adaptively constructs feasible CMEs based on constrained quadratic optimization. Moreover I will show how a well-known interior point optimization strategy called primal log barrier method can be suitably adapted to solve the quadratic problem faster than commercial solvers.

3 - Confidence Interval Computation for Stochastic Variational Inequalities

Michael Lamm, University of North Carolina at Chapel Hill, Hanes Hall, CB 3260, Chapel Hill, NC, United States of America, mlamm@live.unc.edu, Shu Lu, Amarjit Budhiraja

Stochastic variational inequalities provide a means for modeling various optimization and equilibrium problems where model data are subject to uncertainty. Often the true form of these problems cannot be analyzed and some approximation is used. This talk considers the use of a sample average approximation (SAA). To quantify the uncertainty in the SAA solution, we consider the computation of individual confidence intervals for components of the true solution. The proposed methods directly account for the possibly piecewise structure of the SAA solution's limiting distribution and maintain their desired asymptotic properties in general settings.

■ WD19

19- Ft. Pitt

Joint Session CP/IP: Graphical Structures for Integer Programming

Cluster: Constraint Programming

Invited Session

Chair: Willem-Jan van Hoeve, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, United States of America, vanhoeve@andrew.cmu.edu

1 - Combined Benders Decomposition and Column Generation for Stochastic Multiactivity Tour Scheduling

Maria Restrepo, PhD Candidate, Applied Mathematics, Polytechnique Montreal and CIRRELT, 2920, Chemin de la Tour, of 3502, Montreal, QC, Canada, maria-isabel.restrepo-ruiz@polymtl.ca, Bernard Gendron, Louis-Martin Rousseau

We present a combined Benders decomposition and column generation (CG) approach to solve multiactivity tour scheduling problems under demand uncertainty. The solution approach iterates between a master problem (solved by CG) that links daily shifts with tour patterns, and a set of subproblems which assign work activities and breaks to the shifts. We exploit the expressiveness of context-free grammars to model the subproblems. Our approach was able to find high-quality solutions on stochastic and deterministic instances dealing respectively with up to three and seven work activities. In addition, our model outperforms the Dantzig-Wolfe reformulation when evaluated on deterministic problems.

2 - Resource Constrained Shortest Hyperpaths in Shift Scheduling

Eric Prescott-Gagnon, Operational Researcher, Jda Software Canada, 4200 Saint-Laurent #407, Montreal, Qc, H2W2R2, Canada, Eric.PrescottGagnon@jda.com, Louis-Martin Rousseau

Resource constrained shortest-paths problems have generated a lot of interest due to their implication as subproblems to column generation formulations of vehicle routing problems. Grammar-based column generation formulations for shift scheduling generate shortest hyper-path subproblems where many side constraints can be modeled through the use of resource and resource extension functions in the subproblems in a similar way to resource constrained shortest paths. Some example of side constraints and corresponding resources will be provided.

3 - Polar Cuts from Relaxed Decision Diagrams

Christian Tjandraatmadja, PhD Student, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, ctjandra@andrew.cmu.edu, Willem-Jan van Hoeve

The most common approach to generate cuts in integer programming is to derive them from the linear programming relaxation. We study the alternative approach of extracting cuts from discrete relaxations known as relaxed decision diagrams, focusing on 0-1 integer programs. Through a connection between decision diagrams and polarity, the proposed algorithm generates cuts that are facet-defining for the convex hull of this discrete relaxation. As proof of concept, we provide computational evidence that this algorithm generates strong cuts for the maximum independent set problem.

■ WD20

20- Smithfield

Recent Advances in ADMM III

Cluster: Nonsmooth Optimization

Invited Session

Chair: Sangwoon Yun, Professor, Sungkyunkwan University, Sungkyunkwan-ro 25-2, Jongro-gu, Seoul, 110-745, Korea, Republic of, sangwoony@gmail.com

1 - A Parallel Splitting Method for Separable Convex Programming with Linear Inequality Constraints

Lingling Xu, Dr., Nanjing Normal University, School of Mathematical Sciences, Nanjing, 210023, China, naco@njnu.edu.cn, Deren Han

In this paper, we proposed an alternating direction method for solving the convex programs where the object function is separable with two operators and the constraint is composed of linear inequalities under some assumptions, we proved the convergence of the proposed method. The linear convergence is obtained when the object function is quadratic.

2 - Convergence of ADMM for Nonconvex Problems Based on the Kurdyka-{\L}ojasiewicz Inequality

Tingting Wu, Dr., School of Science, Nanjing University of Posts and Telecommunications, #9 Culture Gardens Road, Nanjing, China, Nanjing, Al, 210023, China, wutt@njupt.edu.cn, Deren Han

The efficiency of the classic alternating direction method of multipliers (ADMM) has been exhibited by various applications for large scale separable optimization problems. In this talk, we first give a review on the Kurdyka-{\L}ojasiewicz (KL) function. Specially, under the assumption that the associated function satisfies the KL inequality, we analyze the convergence of ADMM for solving two-block linearly constrained nonconvex minimization model whose objective function is the sum of two nonconvex functions without coupled variables. Under some further conditions on the problem's data, we also analyze the rate of convergence of the algorithm, which are related to the flatness of the functions by means of KL exponents.

■ WD21

21-Birmingham

Advances in Derivative-Free Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Francesco Rinaldi, Department of Mathematics University of Padua, via Trieste, 73, Padua, Italy, rinaldi@math.unipd.it

1 - Parallelized Hybrid Optimization Methods for Nonsmooth Problems using NOMAD and Linesearch

Klaus Truemper, Prof. Em. of CS, University of Texas at Dallas, 800 W Campbell Rd, Richardson, TX, 75080, United States of America, klaus@utdallas.edu, Giampaolo Liuzzi

A parallelized hybrid method is presented for single-function optimization problems with side constraints. It consists of the well-known method NOMAD and two new methods called DENCON and DENPAR that are based on the linesearch scheme CS-DFN. The method has been tested on a set of difficult optimization problems produced by a certain seeding scheme for multiobjective minimization. The results are compared with solution of the problems by NOMAD, DENCON, and DENPAR running as stand-alone methods. It turns out that in the stand-alone comparison, NOMAD is significantly better than DENCON and DENPAR, but that the hybrid method is definitely superior to NOMAD.

2 - A Linesearch Derivative-Free Method for Bilevel Minimization Problems

Stefano Lucidi, University of Rome, La Sapienza, via Ariosto, 25, Rome, Italy, lucidi@dis.uniroma1.it, Stefania Renzi

In this work we propose a new linesearch derivative-free algorithm for bilevel minimization problems. Under suitable assuptions we prove that an accumulation point of the sequence produced by the argorithm is a stationary point of the considered problem. We also report the results of a preliminary numerical experience showing a possible practical interest of the proposed approach.

3 - Global Optimization Applied to a Fluids Simulation in an Automated Workflow

Taylor Newill, North American Technical Manager, Noesis Solutions, 35 E Main St., Ste 300, Carmel, IN, 46032, United States of America, taylor.newill@noesissolutions.com

Recent advancements in machine learning and adaptive simulation strategies has enhanced both the speed and accuracy for optimizing computer assisted engineering (CAE) physics problems. In this presentation we will demonstrate methods for capturing a workflow that includes fluid and structural simulation and then compare classical derivative free optimization methods with new machine learning and advanced derivative free optimization methods that are available inside of a commercial process integration and design optimization tool (PIDO). The machine learning and adaptive methods that are used will be discussed in detail.

■ WD22

22- Heinz

Variational Analysis in Nonsmooth Optimization III

Cluster: Variational Analysis

Invited Session

Chair: Martin Knossalla, University of Erlangen-Nuremberg, Cauerstr. 11, Erlangen, 91058, Germany, martin.knossalla@fau.de

1 - Selective Linearization Algorithm for Multi-block Convex Optimization

Yu Du, Rutgers University, 100 Rockafeller Road, Room 5111, Piscataway, NJ, 08854, United States of America, duyu@rutgers.edu, Xiaodong Lin, Andrzej Ruszczynski

We consider the problem of minimizing the multi-block structured convex non-smooth functions. We introduce the Selective Linearization(SLIN) Algorithm which iteratively solves a series of subproblems by linearizing some blocks and approaches the optimal solution. Global convergence is achieved and SLIN algorithm is proven to converge at rate of $O(1/k)$, where k is the number of iterations. We apply the SLIN algorithm on image recovery and matrix completion applications, showing fast running time for large scale problems.

2 - Too Relaxed? Tight Relaxation using Non-Convex Regularization

Ankit Parekh, Department of Mathematics, School of Engineering, New York University, 6, Metrotech, Jay Street, Brooklyn, NY, 11201, United States of America, ankit.parekh@nyu.edu, Ivan Selesnick

We consider the problem of signal denoising using a sparse tight-frame analysis prior. The L1 norm has been extensively used as a regularizer to promote sparsity; however, it tends to under-estimate non-zero values of the underlying signal. To more accurately estimate non-zero values, we propose the use of a non-convex regularizer, chosen so as to ensure convexity of the objective function. The convexity of the objective function is ensured by constraining the parameter of the non-convex penalty. We use ADMM to obtain a solution and show how to guarantee that ADMM converges to the global optimum of the objective function. We illustrate the proposed method for 1D and 2D signal denoising.

3 - Minimization of Locally Lipschitzian Functions using Outer Subdifferentials

Martin Knossalla, University of Erlangen-Nuremberg, Cauerstr. 11, Erlangen, 91058, Germany, martin.knossalla@fau.de

The theory of subdifferentials provides adequate methods and tools to put descent methods for nonsmooth optimization problems into practice. But there is often no exact information about the whole subdifferential. In this cases the semismoothness of the cost functions cannot be proven or is violated. Basing on the continuous outer subdifferentials we developed, this talk presents a new strategy for optimization problems with local Lipschitzian cost functions. Especially the semismoothness of the cost function will not be taken for granted. A descent method based on this outer subdifferentials will be developed and its convergence will be proven.

■ WD23

23- Allegheny

Multi-Objective Branch and Bound

Cluster: Multi-Objective Optimization

Invited Session

Chair: Kim Allan Andersen, Aarhus University, Fuglesangs Allé 4, Aarhus, 8210, Denmark, kia@econ.au.dk

1 - PolySCIP - A Solver for Multi-Criteria Mixed Integer Programs

Sebastian Schenker, TU Berlin / Zuse Institute, Strafle des 17. Juni 136, Berlin, 10623, Germany, schenker@zib.de

Multi-criteria optimization can be considered as a generalization of single-objective optimization. However, compared to the single-objective case the variety of solvers available to the community is very sparse. Furthermore, there exist no common input format or common language for modeling multi-criteria problems. In this talk I want to present PolySCIP - a solver for multi-criteria mixed integer programs. It is based on the free non-commercial solver SCIP. In this talk I will present the underlying theoretical approach which uses a weight space partition as well as practical issues like modeling options and input formats.

2 - A Parallel Bi-Objective Branch and Bound Algorithm

Kim Allan Andersen, Aarhus University, Fuglesangs Allé 4, Aarhus, 8210, Denmark, kia@econ.au.dk, Thomas Stidsen

Two of the authors have earlier developed a Branch and Bound algorithm for bi-objective problems, that can determine all non-dominated points. That algorithm is parallelized. We present the parallelized algorithm, and explain how the algorithm can be designed such that it can be implemented in an efficient way. Computational experiments has revealed that the algorithm performs well.

3 - Optimized Parallelization of a Bi-Objective Branch & Cut Algorithm

Thomas Stidsen, Technical University of Denmark, Produktionstorvet, Bygning 426, Lyngby, 2800, Denmark, thst@dtu.dk, Kim Allan Andersen

To solve Bi-Objective TSP problems of non-trivial size, a parallel Branch & Cut algorithm is developed. The problem is solved in parallel, divided in such a way that no communication between the different algorithms is needed. The division is optimized, such that an efficient parallelization is achieved. Optimal solutions, i.e. the full Pareto front, is found for the most used dataset.

■ WD24

24- Benedum

Theory of Mixed-integer Optimization

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Alberto Del Pia, Assistant Professor, University of Wisconsin - Madison, Madison, WI, United States of America, delpia@wisc.edu

1 - Techniques for Gomory and Johnson's Infinite Group Problem

Amitabh Basu, Johns Hopkins University, Whitehead Hall, 3400 N Charles St, Baltimore, MD, 21218, United States of America, abasu9@jhu.edu, Robert Hildebrand, Matthias Koeppe

We describe some of the tools recently developed for analyzing Gomory and Johnson's Infinite Group problem. In particular, we will present higher dimensional generalizations of the so-called Interval Lemma, and give the details of the first ever algorithm for testing extremality of piecewise linear functions with rational breakpoints.

2 - On the Polyhedrality of the t-branch Closure

Diego Moran, Assistant Professor, ISE, Virginia Tech, 227 Durham Hall, 1145 Perry Street, Blacksburg, VA, 24061, United States of America, damr@vt.edu, Sanjeeb Dash, Oktay Gunluk

In this talk we study properties of the t-branch split cuts introduced by Li and Richard (2008). A t-branch split cut is an inequality that is valid for the set obtained by removing from a polyhedron the union of t split sets. This notion is a generalization of split cuts (1-branch split cuts). Cook et al. (1990) showed that the split closure of a rational polyhedron is again a polyhedron and Dash et al (2013) showed that cross cuts (2-branch splits cuts) also yield closures that are rational polyhedra. We further extend these results and show that the t-branch split closure is a polyhedron for all t=1,2,... .

3 - Extreme Cut Generating Functions are Dense in Set of Minimal Functions

Robert Hildebrand, Postdoc, ETH Zurich, Karstlernstrasse, 2, Zurich, 8048, Switzerland, robert.hildebrand@ifor.math.ethz.ch, Amitabh Basu, Marco Molinaro

In the context of general purpose cutting planes for linear integer programs, several models have been used for studying cut generating functions. This study focuses on determining valid cut generating functions based only on the optimal solution to the linear programming relaxation. These functions take as input the coefficients on the non-basic variables in the simplex tableau. Non-dominated valid functions are called minimal, and minimal functions that are not the convex combination of others are called extreme. For Gomory and Johnson's model for studying these functions, we show that the set of extreme functions is dense in the set of minimal functions.

■ WD25

25- Board Room

Energy Market Modelling

Cluster: Optimization in Energy Systems

Invited Session

Chair: Afzal Siddiqui, University College London, Department of Statistical Science, Gower Street, London, WC1E 6BT, United Kingdom, afzal.siddiqui@ucl.ac.uk

1 - A Dynamic Equilibrium Model of the US Crude Oil Market

Olufolajimi Oke, Systems Institute, Department of Civil Engineering, Johns Hopkins University, 3400 N Charles St, Baltimore, MD, 21218, United States of America, ooke1@jhu.edu, Max Marshall, Daniel Huppmann, Sauleh Siddiqui

The recent US shale oil boom has been constrained by a lack of refinery capacity, insufficient transportation infrastructure and an export ban on crude oil. One notable consequence of the refinery and transit limitations is the rise of crude oil shipments via rail, which has been of great concern for the environment and public safety. We adapt Huppmann and Egging's dynamic energy market equilibrium model to the current US crude oil system and its interaction with other global players. We quantitatively characterize the US market and analyze scenarios to inform appropriate policy responses to critical economic and environmental impacts of crude oil production and movement within the US.

2 - Energy and Climate Market Policy using Multiobjective Programs with Equilibrium Constraints

Sauleh Siddiqui, Assistant Professor, Systems Institute, Departments of Civil Engineering and Applied Math & Statistics, Johns Hopkins University, 3400 N Charles St, Baltimore, MD, 21218, United States of America, siddiqui@jhu.edu, Adam Christensen

Energy and climate market policy is inherently multiobjective and multilevel, in that a set of desired choices often conflict and are made at a higher level than influenced actors. Multiobjective optimization problems allow the study of tradeoff between choices, while equilibrium problems model the networks and players over which these policies are chosen. Combining these two types of optimization problems produces a formulation called a Multiobjective Program with Equilibrium Constraints (MOPEC). We present a MOPEC to model the biofuels market, with the upper-level giving policy choices of volume obligations for the Renewable Fuel Standard.

3 - Congestion Management in a Stochastic Dispatch Model for Electricity Markets

Endre Björndal, Associate Professor, Norwegian School of Economics, Helleveien 30, Bergen, 5045, Norway, Endre.Bjorndal@nhh.no, Golbon Zakeri, Mette Björndal, Kjetil Midthun

We discuss the design of electricity markets with stochastic dispatch. Our discussion is based on a model framework similar to that in (Pritchard et al. 2010) and (Morales et al. 2014), where an electricity market with two sequential market clearings is used. The stochastic market clearing is compared to the (standard) myopic market model in a small example, where wind power generation is uncertain. We examine how changes in market design influence the efficiency of the stochastic dispatch. In particular, we relax the network flow constraints when clearing the day ahead market. We also relax the balancing constraints when clearing the day ahead market to see if this additional flexibility can be valuable to the system.

■ WD26

26- Forbes Room

Bounding and Sampling Methods

Cluster: Stochastic Optimization

Invited Session

Chair: Harikrishnan Sreekumaran, Purdue University, West Lafayette IN 47906, United States of America,

harikrishnan@purdue.edu

1 - Monotonic Bounds and Approximation in Multistage Stochastic Programs

Francesca Maggioni, Assistant Professor, University of Bergamo, Via dei Caniana n 2, Bergamo, BG, 24127, Italy, francesca.maggioni@unibg.it

Consider multistage stochastic programs, which are defined on scenario trees as the basic data structure. The computational complexity of the solution depends on the size of the tree, which itself increases typically exponentially fast with the number of decision stages. For this reason approximations which replace the problem by a simpler are of importance. In this talk we study several methods to obtain lower and upper bounds for multistage stochastic programs both in linear and non-linear cases. Chains of inequalities among the new quantities are provided and proved in relation to the optimal objective value, WS and EEV. Numerical results on a multistage inventory problem and on a real case transportation problem are provided.

2 - Adaptive Importance Sampling via Stochastic Convex Programming

Ernest Ryu, Stanford University, 243 Packard, Stanford, CA, 94305, United States of America, eryu@stanford.edu, Stephen Boyd

In this talk we present a new application of convex optimization: Monte Carlo simulation. We first show that the variance of the Monte Carlo estimator that is importance sampled from an exponential family is a convex function of the natural parameter of the distribution. With this insight, we propose an adaptive importance sampling algorithm that simultaneously improves the choice of sampling distribution while accumulating a Monte Carlo estimate. Exploiting convexity, we prove that the method's unbiased estimator has variance that is asymptotically optimal over the exponential family.

3 - Distributed Algorithms for Games under Exogenous Uncertainty

Harikrishnan Sreekumaran, Purdue University, 315 N Grant St., West Lafayette, IN, 47906, United States of America, harikrishnan.sreekumaran@gmail.com, Andrew Liu

We analyze distributed/parallel algorithms for computing Nash equilibria of certain classes of games under exogenous uncertainty. Specifically we study potential games and supermodular games, with the purpose of establishing conditions under which sequential Gauss Seidel or parallel Gauss Jacobi type methods converge to equilibria under uncertainty, when combined with various sampling schemes. Numerical results for the proposed approach will be presented for applications such as network design games.

■ WD27

27- Duquesne Room

Efficient Algorithms for Inventory Control with Combinatorially Growing State-space

Cluster: Combinatorial Optimization

Invited Session

Chair: David Goldberg, Assistant Professor, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, GA, 30332-0205, United States of America, dgoldberg9@isye.gatech.edu

1 - Asymptotic Optimality of TBS Policies in Dual-Sourcing Inventory Systems

David Goldberg, Assistant Professor, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, GA, 30332-0205, United States of America, dgoldberg9@isye.gatech.edu, Linwei Xin

Dual-sourcing inventory systems arise in many supply chains, but are notoriously difficult to optimize due to the curse of dimensionality. Recently, Tailored Base-Surge (TBS) policies have been proposed as a heuristic, and have been found to perform well in numerical experiments. We provide a theoretical foundation for this good performance by proving that a simple TBS policy is asymptotically optimal as the lead time of the regular source grows large. Our proof combines novel convexity and lower-bounding arguments, an interchange of limits, and ideas from the theory of random walks, significantly extending the methodology and applicability of a novel framework recently introduced by Goldberg et al.

2 - Distributionally Robust Inventory Control when Demand is a Martingale

Linwei Xin, Georgia Institute of Technology, 765 Ferst Dr. NW, Atlanta, GA, 30332, United States of America, lwxin@gatech.edu, David Goldberg

Independence of random demands across different periods is typically assumed in multi-period inventory models. In this talk, we consider a distributionally robust model in which the sequence of demands must take the form of a martingale with given mean and support. We explicitly compute the optimal policy and value, and shed light on the interplay between the optimal policy and worst-case distribution. We also draw some interesting conclusions about the difference between the "independence" and "martingale" models.

3 - Data-Driven Algorithms for Nonparametric Multi-Product Inventory Systems

Cong Shi, Assistant Professor, University of Michigan, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, shicong@umich.edu, Weidong Chen, Izak Duenyas

We propose a data-driven algorithm for the management of stochastic multi-product inventory systems with limited storage as well as production cost uncertainty. The demand distribution is not known a priori and the manager only has access to past sales data (often referred to as censored demand data). In addition, the manager does not know the production cost distribution for each product and can only collect past realized cost data. We measure performance of our proposed policy through regret, the difference between the expected cost of the policy and that of an oracle with access to the true demand and cost distributions acting optimally. We characterize the rate of convergence guarantee of our algorithm.

■ WD28

28- Liberty Room

Bilevel Optimization

Cluster: Global Optimization

Invited Session

Chair: Oleg A. Prokopyev, University of Pittsburgh, 3700 O'Hara Street, Benedum Hall 1048, Pittsburgh, PA, 15261-3048, United States of America, prokopyev@engr.pitt.edu

1 - Bilevel Integer Optimization: Theory and Algorithms

Ted Ralphs, Professor, Lehigh University, 200 W Packer Avenue, Bethlehem, PA, 18015, United States of America, ted@Lehigh.edu, Sahar Tahernajad

Bilevel integer optimization problems form a challenging but important class of problems that arise in many real applications. In this talk, we first present a theoretical framework, focusing on the challenges that must be overcome in order to develop solution techniques, as well as on providing some insight into the source of the apparent empirical difficulty of solving these problems. In the second part, we describe several related algorithms and our recent attempts at solving these problems in practice.

2 - Reformulation and Decomposition Method for Bilevel Mixed Integer Nonlinear Programs

Liang Xu, USF, 4202 E Fowler, Tampa, United States of America, liangxu@mail.usf.edu, Yu An, Bo Zeng

Based on our study on bilevel mixed integer linear problems, we consider a few classes of bilevel mixed integer nonlinear problems, including those with a mixed integer quadratic program and a mixed integer second order conic program as their lower level problems. Structural analysis and computational studies will be presented to validate our algorithm.

3 - On Pessimistic Versus Optimistic Bilevel Linear Programs

M. Hosein Zare, University of Pittsburgh, 1048 Benedum Hall, Pittsburgh, PA, 15261, United States of America, mhossein.zare@gmail.com, Osman Ozaltin, Oleg A. Prokopyev

We study the relationships between Pessimistic and Optimistic Bilevel Linear Programs. In particular, we focus on the case when the upper-level decision-maker (i.e., the leader) needs to consider the uncertain behavior of the lower-level decision maker (i.e., the follower). We derive some computational complexity properties, and illustrate our results using a defender-attacker application.

■ WD29

29- Commonwealth 1

First Order Optimization Methods for Nonsmooth Problems

Cluster: Nonsmooth Optimization

Invited Session

Chair: Olivier Fercoq, Post-doctoral Fellow, Telecom ParisTech, 37 rue Dareau, Paris, 75014, France, olivier.fercoq@telecom-paristech.fr

1 - Doubly Stochastic Primal-Dual Coordinate Descent Method for the Recovery of Random Reduction

Qihang Lin, Assistant Professor, The University of Iowa, S380 Pappajohn Business Building, The University of Iowa, Iowa City, IA, 52242-1994, United States of America, qihang-lin@uiowa.edu, Tianbao Yang, Adam Wei Yu

Randomized reduction methods can be applied to large-scale and high-dimensional machine learning problems in order to reduce either the dimensionality or the number of training instances. However, the lack of fast algorithms for recovering the parameters for the original model has hindered the broad application of randomized reduction methods in data analysis. In this paper, we propose a doubly stochastic primal-dual coordinate descent method for the recovery of random reduction. By utilizing the factorized structure of reduced models, our method achieve a low computational complexity than existing coordinate methods when the size of data is huge.

2 - Primal-Dual Coordinate Descent

Olivier Fercoq, Post-doctoral fellow, Telecom ParisTech, 37 rue Dareau, Paris, 75014, France, olivier.fercoq@telecom-paristech.fr, Walid Hachem, Pascal Bianchi

Many optimization problems can be formulated as saddle point problems of the form "max min $f(x) + g(x) - h^*(y) + < K x, y >$," where K is a linear map, f, g, h are convex functions, f is differentiable, g and h have simple proximal operators. Basing on the theory of monotone operators, Bianchi et al. proposed a coordinate descent method for this problem. However, the efficiency of coordinate descent for large scale problems comes from its stepsizes that are longer than the gradient method's. We extend Bianchi et al.'s method in order to combine long stepsizes and the ability to deal with saddle point problems. We prove that the gap of the Lagrangian function decreases at a rate $O(1/k)$ and recover the convergence of Vu-Condat algorithm.

3 - Linearly Convergent Conditional Gradient Variants for Non-strongly Convex Functions

Shimrit Shtern, Technion - Israel Institute of Technology, Department of Industrial Engineering,, Technion City, Haifa, 3200003, Israel, shimrits@tx.technion.ac.il, Amir Beck

Two variants of the conditional gradient algorithm — the local conditional gradient and the away step conditional gradient — are known to converge linearly for minimizing a strongly convex function over a polyhedral set. We prove that these algorithms also admit a linear rate of convergence for well-structured functions, which are not strongly convex. Moreover, for the version that incorporates away steps, we provide a new convergence rate with computable constants that also enables the comparison between the two algorithms.

■ WD30

30- Commonwealth 2

Approximation and Online Algorithms X

Cluster: Approximation and Online Algorithms
Invited Session

Chair: Clifford Stein, Columbia University, Columbia University, New York, NY, 10027, United States of America, cliff@ieor.columbia.edu

1 - Stochastic Scheduling of Heavy-tailed Jobs

Kirk Pruhs, University of Pittsburgh, Computer Science Department, Pittsburgh, PA, 16059, United States of America, kirk@cs.pitt.edu, Benjamin Moseley, Sungjin Im

We revisit the classical stochastic scheduling problem of nonpreemptively scheduling n jobs so as to minimize total completion time on m identical machines, P | | E[Sum C_j] in the standard 3-field scheduling notation. Previously it was only known how to obtain reasonable approximation if jobs sizes have low variability. We show that the natural list scheduling algorithm Shortest Expected Processing Time has a bad approximation ratio for high variability jobs. We develop a list scheduling algorithm that is O(log^2 n + m log n)-approximate. Intuitively our list scheduling algorithm finds an ordering that not only takes the expected size of a job into account, but also takes into account the probability that job will be big.

2 - Hallucination Helps: Energy Efficient Virtual Circuit Routing

Clifford Stein, Columbia University, Columbia University, New York, NY, 10027, United States of America, cliff@ieor.columbia.edu, Sungjin Im, Benjamin Moseley, Antonios Antoniadis, Viswanath Nagarajan, Kirk Pruhs, Ravishankar Krishnaswamy

We give online and offline approximation algorithms for energy efficient circuit routing protocols for a network of components that are speed scalable, and that may be shutdown when idle. The components may be either edges or nodes. For edges, we describe a polynomial-time offline algorithm that has a poly-log approximation ratio. The key step of the algorithm design is a random sampling technique that we call hallucination. The algorithm extends to an online algorithm, whose analysis introduces a natural ``priority" multicommodity flow problem, and bounds the priority multicommodity flow-cut gap. We will then extend the results to the more involved case when the components are vertices and give an offline algorithm.

3 - Resource Augmentation Algorithm for Single Machine Scheduling with Job-Dependent Convex Cost

Rodrigo Carrasco, Universidad Adolfo Ibanez, Diagonal Las Torres 2640, Santiago, Chile, rodrigo.carrascos@uai.cl

We present an algorithm that combines resource augmentation and alpha-point scheduling techniques, both of which have resulted in very good performance scheduling algorithms, to compute approximate solutions for a general family of scheduling problems: each job has a convex non-decreasing cost function and the goal is to compute a schedule that minimizes the total cost subject to precedence constraints. We show that our algorithm is a O(1)-speed 1-approximation algorithm and our numerical experiments show that the speed-scaling ratio required is close to 1.

Wednesday, 4:35pm - 5:25pm

■ WE01

01- Grand 1

A Geometric Approach to Cut-Generating Functions

Cluster: Plenary
Invited Session

Chair: Gerard Cornuejols, Carnegie Mellon Univ., Tepper School of Business, Pittsburgh, United States of America, gc0v@andrew.cmu.edu

1 - A Geometric Approach to Cut-Generating Functions

Michele Conforti, Universita degli Studi di Padova, Via Trieste 63, Department of Mathematics, Padova, Italy, conforti@math.unipd.it

The cutting-plane approach to integer programming was initiated more that 40 years ago: Gomory introduced the corner polyhedron as a relaxation of a mixed integer set in tableau form and Balas introduced intersection cuts for the corner polyhedron. This line of research was left dormant for several decades until relatively recently, when a paper of Andersen, Louveaux, Weismantel and Wolsey generated renewed interest in the corner polyhedron and intersection cuts. Recent developments rely on tools drawn from convex analysis, geometry and number theory, and constitute an elegant bridge between these areas and integer programming. We survey these results and highlight recent breakthroughs in this area.

■ WE02

02- Grand 2

Optimization Challenges in Tensor Factorization

Cluster: Plenary
Invited Session

Chair: Sven Leyffer, Argonne National Laboratory, 9700 South Cass Ave, Argonne, IL, United States of America, leyffer@mcs.anl.gov

1 - Optimization Challenges in Tensor Factorization

Tamara G. Kolda, Sandia Labs, tgkolda@sandia.gov

Tensors are multiway arrays, and tensor decomposition is a powerful tool for compression and data interpretation. In this talk, we demonstrate the utility of tensor decomposition with several examples and explain the optimization challenges, both theoretical and practical. The optimization problems are nonconvex, but they can typically be solved via an alternating approach that yields convex subproblems. We consider open problems such as determining the model complexity, tensor completion, incorporating symmetries and other constraints, handling ambiguities in scaling and permutation, enforcing structure like sparsity, and considering alternative objective functions.

Wednesday, 5:30pm - 6:20pm

■ WF06

01- Grand 1

Tseng Memorial Lecture

Cluster: Plenary
Invited Session

Chair: Yinyu Ye, Professor, Stanford University, Dept. of Management Science and Eng., Stanford University, Stanford, CA, 94305, United States of America, yinyu-ye@stanford.edu

1 - Tseng Memorial Lectureship

Yinyu Ye, Professor, Stanford University, Dept. of Management Science and Eng., Stanford University, Stanford, CA, 94305, United States of America, yinyu-ye@stanford.edu

The purposes of the lectureship are to commemorate the outstanding contributions of Professor Tseng in continuous optimization and to promote the research and applications of continuous optimization in the Asia-Pacific region.

Thursday, 9:00am - 9:50am

■ ThA01

01- Grand 1

A Distributionally Robust Perspective on Uncertainty Quantification and Chance Constrained Programming

Cluster: Plenary
Invited Session

Chair: Andrew J. Schaefer, University of Pittsburgh, 3700 O'Hara Street, Benedum Hall 1048, Pittsburgh, PA, 15261-3048, United States of America, schaefer@ie.pitt.edu

1 - A Distributionally Robust Perspective on Uncertainty Quantification and Chance Constrained Programming

Daniel Kuhn, EPFL, EPFL-CDM-MTEI-RAO, Station 5, Lausanne, Switzerland, daniel.kuhn@epfl.ch

The objective of uncertainty quantification is to certify that a given physical, engineering or economic system satisfies multiple safety conditions with high probability. A more ambitious goal is to actively influence the system so as to guarantee and maintain its safety, a scenario which can be modeled through a chance constrained program. In this talk we assume that the parameters of the system are governed by an ambiguous distribution that is only known to belong to an ambiguity set characterized through generalized moment bounds and structural properties such as symmetry, unimodality or independence patterns. We delineate the watershed between tractability and intractability in ambiguity-averse uncertainty quantification and chance constrained programming. Using tools from distributionally robust optimization, we derive explicit conic reformulations for tractable problem classes and suggest efficiently computable conservative approximations for intractable ones.

Thursday, 10:20pm - 11:50pm

■ ThB01

01- Grand 1

Linear Complementarity Problem and Related Matrix Classes

Cluster: Complementarity/Variational Inequality/Related Problems
Invited Session

Chair: Samir Kumar Neogy, Professor, Indian Statistical Institute, Room No. 318 (Faculty Block), 7, S. J. S. Sansanwal Marg, New Delhi, 110016, India, skn@isid.ac.in

1 - On Various Subclasses of P0, N0, Q0 Matrices and the Linear Complementarity Problem

Samir Kumar Neogy, Professor, Indian Statistical Institute, Room No. 318 (Faculty Block), 7, S. J. S. Sansanwal Marg, New Delhi, 110016, India, skn@isid.ac.in

Various classes of matrices that are defined based on their principal minors have been considered in the literature on matrix analysis and the linear complementarity problem (LCP). A subclass of P0 occurs in Markov chain analysis and a subclass of N0-matrices arises in the theory of global univalence of functions, multivariate analysis. In this talk, we study sub-classes of three matrix classes, namely, P0, N0, Q0 matrices that are relevant to LCP and discuss properties of these subclasses. Further we identify some new subclasses. Our observations on the properties of these subclasses can motivate further applications in matrix theory and extend the class of LCPs solvable by Lemke's algorithm.

2 - On Linear Complementarity Problem with a Hidden-Z Matrix

Dipti Dubey, NBHM Post-Doctoral Student, Indian Statistical Institute, Faculty Block (Room no. 315), 7, S. J. S. Sansanwal Marg, New Delhi, 110016, India, diptidubey@isid.ac.in

A variety of classes of matrices are introduced in the context of the linear complementarity problem (LCP). These matrix classes play an important role for studying the theory and algorithms of LCP. Most of the matrix classes encountered in the context of LCP are commonly found in several applications. The class of hidden Z-matrices was studied by Mangasarian and Pang in 80s and linear programming formulations are given to solve LCP for various special cases. Recently Chu studied a subclass of Hidden Z-matrices. We again revisit the classes of hidden Z-matrices and discuss some new results.

3 - Bilevel Programming Models: Reduction of Dimension of the Upper Level Problem

Vyacheslav Kalashnikov, Assist. Prof., TecnolÓgico de Monterrey, Avenida Eugenio Garza Sada 2501 Sur, Monterrey, NL, 64849, Mexico, kalash@itesm.mx, Nataliya Kalashnykova

We treat a problem of reducing the upper level dimension in bilevel programs. In order to diminish the number of the leader's variables, we create a second follower with the same objective function as the leader's, and drop some variables to the lower level. The lower level problem is also modified to a Nash equilibrium problem for both followers. We search conditions guaranteeing that the modified and the original bilevel programming problems share optimal solutions.

■ ThB02

02- Grand 2

Transmission Planning and Operations with Integer Decisions

Cluster: Optimization in Energy Systems
Invited Session

Chair: Ross Baldick, Professor, University of Texas at Austin, 1 University Station C0803, Austin, TX, 78712, United States of America, baldick@ece.utexas.edu

1 - Modeling and Reformulations of Flexible AC Transmission System (FACTS) Devices in Power Systems

Mostafa Ardakani, Post Doctoral Scholar, Arizona State University, P.O. Box 875706, GWC 206, School of ECEE, Tempe, AZ, 85287-5706, United States of America, mostafa@asu.edu, Kory Hedman

Inclusion of variable impedance FACTS devices in the DC optimal power flow problem, originally a linear program (LP), changes it to a non-linear program (NLP). This paper reformulates the NLP to a mixed integer linear program. Engineering insight is then introduced to create a very efficient LP approximation. This would make enhanced operation of FACTS devices an immediate practical possibility. The application of the method for economic and corrective of FACTS adjustment is discussed.

2 - Reducing the Candidate Line List for Practical Integration of Switching into Power System Operation

Mohammad Majidi, University of Texas at Austin, 1616 Guadalupe UTA 2.304, Austin, TX, 78712-1684, United States of America, m.majidi@utexas.edu, Ross Baldick

Optimized operation of the transmission network is one solution to supply extra demand by more efficient use of transmission facilities, and line switching is one main tool to achieve this goal. In this paper, we add extra constraints to OPF formulation to limit the maximum number of switching operations in every hour based on network conditions, and add switching cost in the objective function to represent extra maintenance cost as a result of frequent switching. We also propose an algorithm to remove less important lines for switching in different loading conditions, so OPF with transmission switching will be solved faster for real-time operation. It is applied to a case study with several operation hours.

3 - Economic Valuation of Topology Changes in a Power Network

Alex Rudkevich, President, Newton Energy Group LLC, 75 Park Plaza, 4th floor, Boston, Ma, 02116, United States of America, arudkevich@negll.com, Michael Caramanis, Evegeniy Goldis, Pablo Ruiz, Richard Tabors

Changes in power transmission networks make significant impact on physical operation and economics of power systems. Attributing the economic value of changing topology is often difficult due to a finite (non-marginal) impact of each topology variation. Our approach is to value topology changes as specially defined point-to-point transactions. We illustrate the validity of this approach by solving the problem of revenue adequacy caused by changes in transmission topology in markets for Financial Transmission Rights (FTRs).

■ ThB03

03- Grand 3

Polyhedral Methods for Combinatorial Optimization Problems

Cluster: Combinatorial Optimization
Invited Session

Chair: Volker Kaibel, OvGU Magdeburg, Universitätsplatz 2, Magdeburg, SA, 39106, Germany, kaibel@ovgu.de

1 - Polyhedral Description of Star Colorings

Marc Pfetsch, Prof., TU Darmstadt, Department of Mathematics, Dolivostr. 15, Darmstadt, 64293, Germany, pfetsch@mathematik.tu-darmstadt.de, Christopher Hojny

Star colorings are graph colorings in which no path with four nodes is colored with two colors. They appear in the context of the computation of sparse Hessians. We investigate the corresponding partial star coloring polytope and its facets. In particular, we deal with complete linear descriptions for special graphs. Although this seems to be very hard already for path graphs and two colors, we give a complete description of the projection onto variables that indicate whether a node is colored in this case. We also present computational experiments with a branch-and-cut algorithm.

2 - Structural Investigation of Piecewise Linearized Flow Problems

Maximilian Merkert, FAU Erlangen-Nürnberg, Department Mathematik, Cauerstrafle 11, Erlangen, 91058, Germany, Maximilian.Merkert@math.uni-erlangen.de, Frauke Liers

We study polyhedra in the context of network flow problems, where the flow value on each arc lies in one of several predefined intervals. This is motivated by nonlinear problems on transportation networks, where nonlinearities are handled by piecewise linear approximation or relaxation. We show how to strengthen the formulation for specific substructures consisting of multiple arcs. For paths of degree-two-nodes we give a complete description. Computational results show the effectiveness of our cutting planes.

3 - Partitioning into Induced Connected Isomorphic Subgraphs

Hendrik Lüthen, Technische Universität Darmstadt, Dolivostrafle 15, Darmstadt, 64293, Germany, luethen@mathematik.tu-darmstadt.de, Marc Pfetsch

Given a graph G and a number k what is the biggest induced connected subgraph H such that G can be partitioned into k isomorphic copies of H and a connected remaining part? We discuss integer programming formulations for this problem and investigate the structure of the polytope of induced connected subgraphs, including facet-defining inequalities.

■ ThB04

04- Grand 4

Copositive and Completely Positive Programming

Cluster: Conic Programming
Invited Session

Chair: Javier Pena, Professor of Operations Research, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, jfp@andrew.cmu.edu

1 - Genericity and Stability in Linear Conic Programming

Mirjam Dür, University of Trier, Department of Mathematics, Trier, 54286, Germany, duer@uni-trier.de, Bolor Jargalsaikhan, Georg Still

We discuss the genericity and stability of properties of linear conic problems. A property is said to be stable at a problem instance if the property still holds under a small perturbation of the problem data. We say that a property is weakly generic if it holds for almost all problem instances. We investigate genericity and stability of Slater's condition, uniqueness of the optimal solution, nondegeneracy, and strict complementarity in conic programming. Moreover, we characterize first order optimal solutions and discuss their stability.

2 - An Algorithm for Computing the CP-Factorization of a Completely Positive Matrix

Kurt Anstreicher, Professor, University of Iowa, Dept. of Management Sciences, Iowa City, IA, 52242, United States of America, kurt-anstreicher@uiowa.edu, Sam Burer, Peter Dickinson

A real symmetric matrix C is completely positive (CP) if C has a CP-factorization of the form C=AA' where A is a nonnegative matrix. Determining whether or not a matrix is CP is an NP-hard problem. We consider a cutting-plane algorithm to determine whether or not a matrix is CP, and if so provide an explicit CP-factorization. Our construction is based on applying a polynomial-time cutting-plane method (for example, the ellipsoid algorithm) using an exponential-time separation oracle for the copositive cone. The resulting algorithm has the best known complexity for computing the CP-factorization of a CP matrix.

3 - A Nonlinear Semidefinite Approximation for Copositive Optimisation

Juan Vera, Assistant Professor, Tilburg University, Room K 533, P.O. Box 90153, Tilburg, 5000 LE, Netherlands, j.c.veralizcano@tilburguniversity.edu, Peter Dickinson

Copositive optimisation has numerous applications, e.g.~exact formulations for combinatorial problems. When solving copositive optimisation problems, one often considers approximations to the copositive cone, e.g.~the Parrilo-cones. While the copositive cone is invariant under scaling these approximations are not, which make the ``approximated solution" sensitive to the scaling of the data. In this talk a method is presented to optimise over the closure under scalings of the approximation cones. This is done using nonlinear semidefinite optimisation, which is in general intractable. However for some problems, including the stability number, quasiconvexity in our method makes it tractable.

■ ThB05

05- Kings Garden 1

Real-Time Optimization and Predictive Control I

Cluster: Nonlinear Programming
Invited Session

Chair: Victor ZavalaComputational Mathematician, Argonne National Laboratory, 9700 South Cass Ave, Argonne, IL, 60439, United States of America, vzavala@mcs.anl.gov

1 - A Parametric Non-Convex Decomposition Algorithm with Application to Distributed Energy Systems

Jean-Hubert Hours, EPFL, Station 9, Lausanne, Switzerland, jean-hubert.hours@epfl.ch, Colin Jones

A novel decomposition scheme to solve parametric non-convex programs as they arise in dynamic optimization is presented. It consists of a fixed number of alternating proximal gradient steps and a dual update per time step. Assuming that the nonlinear program is semi-algebraic and that its critical points are strongly regular, contraction of the sequence of primal-dual iterates is proven, implying stability of the sub-optimality error, under some mild assumptions. Moreover, it is shown that the performance of the optimality-tracking scheme can be enhanced by combining it with an inexact Newton method in a trust-region framework. Efficacy of the proposed decomposition method is demonstrated by solving various problems in power systems.

2 - Stability and Robustness of Model Predictive Control with Discrete Actuators

James Rawlings, Professor, Department of Chemical and Biological Engineering, University of Wisconsin, Madison, WI, 53705, United States of America, rawlings@engr.wisc.edu, MIchael Risbeck

Model predictive control (MPC) has become the dominant advanced control method deployed by the process industries. As MPC continues to spread into other industrial fields it becomes increasingly relevant to consider discrete-valued (on/off switches) as well as continuous-valued (flows, voltages, torques) actuators. This paper reviews the extensive research literature discussing the control theoretic properties of MPC in this setting, and proposes a unifying framework for assessing and extending these known results. Topics covered include: nominal stability and recursive feasibility for both optimal and suboptimal MPC, robustness to disturbances, and extensions to distributed and economic MPC.

3 - Bridging the Gap Between Multigrid, Hierarchical, and Receding-horizon Control

Victor Zavala, Computational Mathematician, Argonne National Laboratory, 9700 South Cass Ave, Argonne, IL, 60439, United States of America, vzavala@mcs.anl.gov

We analyze the structure of the Euler-Lagrange conditions of a lifted long-horizon optimal control problem. The analysis reveals that the conditions can be solved by using block Gauss-Seidel schemes and we prove that such schemes can be implemented by solving sequences of short-horizon problems. The analysis also reveals that a receding-horizon control scheme is equivalent to performing a single Gauss-Seidel sweep. We also derive a strategy that uses adjoint information from a coarse long-horizon problem to correct the receding-horizon scheme and we observe that this strategy can be interpreted as a hierarchical control architecture. Our results bridge the gap between multigrid, hierarchical, and receding-horizon control.

■ ThB06

06- Kings Garden 2

Mixed-Integer Nonlinear Optimal Control and Traffic II

Cluster: Mixed-Integer Nonlinear Programming
Invited Session

Chair: Sebastian SagerProf. Dr., Otto-von-Guericke Universität Magdeburg, Universitätsplatz 2, Magdeburg, 39106, Germany, sager@ovgu.de

1 - Convex Control Synthesis for Semiautonomous Vehicles

Ram Vasudevan, Assistant Professor, University of Michigan, G058 WE Auto Lab, 1231 Beal Avenue, Ann Arbor, MI, 48105, United States of America, ramv@umich.edu

Active safety systems in vehicles rely upon first predicting when a driver's input renders a vehicle unsafe and then determining an appropriate intervention policy to maintain safety. Due to the presence of friction, vehicle dynamics are modeled as hybrid dynamical systems. In this talk, we describe a novel semidefinite programming hierarchy, with provably vanishing conservatism, to efficiently propagate uncertainty through vehicle dynamics with semialgebraic state and input constraints while simultaneously synthesizing feedback control inputs for a semiautonomous architecture that preserve safety.

2 - Bilevel Structure Arising in Optimal Scheduling Problems

Konstantin Palagachev, Bundeswehr Universität, Werner-Heisenberg-Weg 39, Neubiberg, 85577, Germany, konstantin.palagachev@unibw.de, Matthias Gerdts

We consider the problem of scheduling multiple tasks and minimising the overall duration of the process. In our formulation, each task is represented by a bilevel optimal control problem, where certain cost functions have to be minimised under imposed constraints. We investigate two different approaches for reducing the bilevel problem into a single level one. In the first one, local necessary optimality conditions are formulated for the lower level problem. In the second one, we reduce the problem to a single level one, introducing new constraints involving the value function of the lower level problem. Both methods lead to a nonlinear mixed-integer optimal control problem, which can be solved by Branch and Bound algorithm.

3 - Real-time Optimal Control of Constrained Hybrid Systems

Damian Frick, PhD Student, ETH Zurich, Physikstrasse 3, Zurich, ZH, 8092, Switzerland, dafrick@control.ee.ethz.ch, Alexander Domahidi, Manfred Morari, Juan Jerez

Optimal control problems involving physical dynamics and logic rules can be formulated using the framework of mixed logical dynamical systems as mixed integer programs. These problems can be solved employing powerful branch-and-bound heuristics. In resource constrained embedded systems it remains unclear how to solve these problems in acceptable runtime. We propose an operator splitting method that performs Euclidean projection computations on non-convex sets at every iteration. These operations are still NP-hard but of lower dimensionality than the original problem. For piecewise affine systems the method converges in few iterations leading to computational times that are not significantly larger than solving convex problems.

■ ThB07

07- Kings Garden 3

Integer Programming Approaches for Routing Problems

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Ricardo Fukasawa, Associate Professor, University of Waterloo, 200 University Ave West, Waterloo, On, N2L3G1, Canada, rfukasawa@uwaterloo.ca

1 - The r-cycle Inequalities for the Time-Dependent Traveling Salesman Problem

Cynthia Rodriguez, University of Waterloo, 200 University Ave W, Waterloo, ON, Canada, ca7rodri@uwaterloo.ca, Ricardo Fukasawa

The Time-Dependent Travelling Salesman Problem (TDTSP) is a generalization of the Travelling Salesman Problem (TSP) in which the cost of the edges depends on their position in the tour. We consider the polytope associated to a formulation for the TDTSP by Picard and Queyranne and focus on the r-cycle inequalities. It is known that the 2-cycle inequalities are facet-defining for the TDTSP polytope. In this talk, we show that the r-cycle inequalities for $r \geq 3$ are (in most cases) also facet-defining for the TDTSP polytope. Finally, we present some computational experiments using the r-cycle inequalities.

2 - Branch-Cut-and-Price for the Chance-Constrained Vehicle Routing Problem with Stochastic Demands

Thai Dinh, Graduate Student/Research Assistant, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI, 53706, United States of America, tndinh@wisc.edu, Ricardo Fukasawa, James Luedtke

We study a chance-constrained model for the vehicle routing problem with stochastic demands. We first derive a valid edge-based formulation, using a lower bound on the minimum number of vehicles required to serve a subset of customers to adapt the well known rounded capacity cuts. We then present a branch-cut-and-price solution framework that requires mild assumptions on the random demands. In particular, the framework can solve problems in which random demands are represented by a scenario model, where the scenarios could be sampled from any distribution. Columns are generated using a dynamic programming algorithm executed over small-cycle-free q-routes with a relaxed capacity constraint. Computational experiments will be presented.

3 - Numerically Safe Lower Bounds for the Capacitated Vehicle Routing Problem

Laurent Poirrier, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, Canada, lpoirrier@uwaterloo.ca, Ricardo Fukasawa

In a branch-and-bound tree, node subproblems are solved in floating-point arithmetic, so numerical errors can occur, leading to inappropriate pruning. We propose two methods for avoiding this issue, in the special case of Capacitated Vehicle Routing Problems (CVRP). With both methods, we construct safely dual feasible solutions of the subproblems and obtain, by weak duality, bounds on their objective function. We show that, in practice, our bounds are stronger than those usually employed, obtained with unsafe arithmetic plus some heuristic tolerance. Moreover, CVRP subproblems are solved by column generation, and we are sometimes able to prune a node before column generation has converged, yielding a modest improvement in performance.

■ ThB08

08- Kings Garden 4

Convex Optimization and Statistical Learning

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Benjamin Recht, UC Berkeley, 465 Soda Hall, MC 1776, Berkeley, CA, 94720, United States of America, brecht@berkeley.edu

1 - Optimization for Sparse Estimation with Strongly Correlated Variables

Robert Nowak, University of Wisconsin-Madison, 1415 Engineering Drive, Madison, United States of America, nowak@ece.wisc.edu

This talk considers ordered weighted L1 (OWL) norm optimization for sparse estimation problems with strongly correlated variables. We show that OWL norm optimization automatically clusters strongly correlated variables, in the sense that the coefficients associated with such variables have equal estimated values. Furthermore, we characterize the statistical performance of OWL norm regularization for generative models in which certain clusters of regression variables are strongly (even perfectly) correlated, but variables in different clusters are uncorrelated.

2 - Sharp Data – Computation Tradeoffs for Linear Inverse Problems

Mahdi Soltanolkotabi, Assistant Professor, University of Southern California, Ming Hsieh Dept. of Elect. Engineeriing, 3740 McClintock Avenue, Los Angeles, CA, 90089, United States of America, soltanol@usc.edu

In many applications one wishes to estimate an unknown but structured signal from linear measurements where the number of measurements is far less that the dimension of the signal. A common approach is to minimize a function subject to linear measurement constraints where the cost function is meant to captures some notion of the complexity of the signal. In this talk, we present a unified theoretical framework for convergence rates of various optimization schemes for solving such problems. Our framework covers convex and non-convex functions. We sharply characterize the convergence rate in terms of the signal size, number of measurements and a precise measure of complexity of the unknown signal. Joint work with B. Recht and S. Oymak.

3 - Resource Allocation for Statistical Estimation

Quentin Berthet, CMI Postdoctoral Fellow, California Institute of Technology, Annenberg Center, Pasadena, CA, 91120, United States of America, qberthet@caltech.edu

Statistical estimation often involves the acquisition, analysis, and aggregation of datasets from heterogenous sources. The appropriate division and assignment of a collection of resources to a set of data sources can therefore substantially impact the overall performance of an inferential strategy. We adopt a general view of the notion of a resource and its effect on the quality of a data source and describe a framework for the allocation of a given set of resources to a collection of sources in order to optimize statistical efficiency. We discuss several inference problems based on heterogeneous data sources, in which optimal allocations can be computed either in closed form or via convex optimization.

■ ThB09

09- Kings Garden 5

Statistics and Optimization

Cluster: Robust Optimization

Invited Session

Chair: Dimitris Bertsimas, Professor of Operations Research and Statistics, Sloan School of Management, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-147, Cambridge, MA, 02139, United States of America, dbertsim@mit.edu

1 - Kalman Filtering through a Robust Optimization Lens

Nishanth Mundru, MIT, United States of America, nmundru@mit.edu, Dimitris Bertsimas

We consider the classical problem of filtering, where we want to estimate the true signal of a linear discrete time system, in the presence of noisy measurements. We analyze this problem using the framework of robust optimization, a tractable methodology of dealing with uncertainty. We show that our approach can accommodate constraints on the state space variables, as well as non Gaussian distributed noise two key drawbacks of the Kalman filter.

2 - On the Equivalence of Robustification and Regularization in Linear, Median, and Matrix Regression

Martin S. Copenhaver, MIT, United States of America, mcopen@mit.edu, Dimitris Bertsimas

Sparsity is a key driver in modern statistical estimation problems, yet reliably sparse solutions remain elusive. Despite this, many regularization methods often perform well in the face of noise in the data. In the domains of linear, median, and matrix regression, we characterize precisely when regularization problems correspond to simple robust optimization problems. In doing so, we contend that it is robustness, not sparsity, which is critical to the success of modern statistical methods.

3 - Regression under a Modern Optimization Lens

Dimitris Bertsimas, Professor of Operations Research and Statistics, Sloan School of Management, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-147, Cambridge, MA, 02139, United States of America, dbertsim@mit.edu, Angie King

Linear regression models are traditionally built through trial and error in order to balance many competing goals such as predictive power, interpretability, significance, robustness to error in data, and sparsity, among others. This problem lends itself naturally to a mixed integer quadratic optimization (MIQO) approach, but has not been modeled this way due to the belief in the statistics community that MIQO is intractable for large scale problems. However, in the last twenty-five years (1990-2014), algorithmic advances in integer optimization combined with hardware improvements have resulted in an astonishing 200 billion factor speedup in solving mixed integer optimization problems. We present an MIQO-based algorithm for designing high-quality linear regression models that explicitly addresses various competing objectives, and demonstrate our algorithm's effectiveness on both real and synthetic datasets.

■ ThB10

10- Kings Terrace

Life Sciences and Healthcare

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Paul Brooks, Virginia Commonwealth University, P.O. Box 843083, Richmond, VA, United States of America, jpbrooks@vcu.edu

1 - Incorporating Coverage for Emergency Calls in Scheduling Patient Transportations

Pieter van den Berg, Delft University of Technology, Mekelweg 4, Delft, 2628 CD, Netherlands, p.l.vandenberg@tudelft.nl, Theresia van Essen

Many ambulance providers operate both advanced life support (ALS) and basic life support (BLS) ambulances. Typically, emergency calls can only be executed by ALS vehicles, whereas non-urgent patient transportations can either be served by an ALS or a BLS ambulance. BLS vehicle capacity does normally not suffice for all transportation requests. The remaining transportations are performed by ALS ambulances, which reduces coverage for emergency calls. We present a model to determine routes for BLS vehicles, so as to maximize the remaining coverage by ALS ambulances.

2 - The L1-Norm Best-Fit Subspace Problem for Robust PCA

Paul Brooks, Virginia Commonwealth University, P.O. Box 843083, Richmond, VA, United States of America, jpbrooks@vcu.edu, Jose Dula

Hospital-level antibiotic resistance data and human microbiome data serve as a motivation for developing robust methods for PCA. We present two methods for PCA based on minimizing the L1 distance of points to fitted (1) hyperplanes and (2) lines. Both problems are naturally written as nonlinear nonconvex optimization problems. Surprisingly, the L1-norm best-fit hyperplane can be found by solving a small number of linear programs. Whether the L1-norm best-fit line can be found in polynomial time remains an open problem. Analysis of relevant linear programming formulations reveals properties of L1 projection on a line. These properties suggest a method for estimating the best-fit line that can also be used for variable selection.

3 - Sparse Mixed-Membership Matrix Factorization via Mixed-Integer Programming

Andrew Trapp, Assistant Professor, Worcester Polytechnic Insitute, 100 Institute Rd., Worcester, MA, 01609, United States of America, atrapp@wpi.edu, Hachem Saddiki, Patrick Flaherty

We consider regularized mixed-membership matrix factorization, where one factor matrix can have a limited number of non-zero entries, and the other has simplex constraints. This provides a mixed-membership representation for each column of the original matrix with sparse mixing components. This problem is known to be NP-Hard, and occurs in a wide variety of contexts, including computational biology, recommendation systems, and image processing. We transform the original biconvex optimization problem into a mixed-integer linear program, and show that moderate-size problems can be solved to global optimality, and that approximate solutions to larger problems can be found via a sequential refinement approach.

■ ThB11

11- Brigade

Combinatorial Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Francisco Barahona, IBM Research, P.O. Box 218, Yorktown Heights, NY, 10607, United States of America, barahon@us.ibm.com

1 - The Maximum Profit Heterogeneous mTSP with Time Windows

Michal Penn, Prof., Technion, Fac. of Ind. Eng. & Mng, Haifa, Israel, mpenn@ie.technion.ac.il, Ilan Tchernowitz, Segev Shlomov, Liron Yedidsion, Amir Beck

We present an algorithm for the heterogeneous multiple traveling salesman problem (mTSP) that consists of determining a set of routes for m heterogeneous salesmen, starting and ending at the depot. We consider time windows, service times and a value for each served customer. The aim is to maximize the total value of the served customers under travel time constraints. Set partitioning formulation over the set of admissible routes is used. To overcome the impracticability of the formulation we create a partial set of admissible routes and then solve to optimality the set partitioning formulation over the chosen partial set. Using this method, we can solve practical problems with more than 70 customers and 12 salesmen.

2 - Simple Extended Formulation for the Dominating Set Polytope via Facility Location

Mourad Baiou, CNRS-LIMOS, mourad.baiou@isima.fr, Francisco Barahona

In this talk we present an extended formulation for the dominating set polytope via facility location. This formulation describes the dominating set polytope for some class of graphs as cacti graphs, though its description in the natural node variables dimension has been only partially obtained. In this case, an important property says that for any integer p, there exists a facet defining inequality having coefficients in 1,...,p. In our extended formulation the inequalities have 0, -1, 1 coefficients. We also give a linear time algorithm to separate the inequalities defining the extended formulation.

3 - On Some Spanning Tree Games

Francisco Barahona, IBM Research, P O Box 218, Yorktown Heights, NY, 10607, United States of America, barahon@us.ibm.com, Mourad Baiou

Given a graph G=(V,E), we study a two-person zero-sum game, where one player, the ''evader,'' picks a spanning tree every few minutes, and sends a signal. A second player, the "inspector," inspects an edge every few minutes. If the signal is being sent through the edge e, the inspector will detect it with probability p(e). We give an "inspection strategy" that maximizes the average probability of detecting the signal, and a "tree-selection" strategy which minimizes the average detection probability. Then we consider a second game, where an "attacker" destroys a set of edges. Then an "inspector" chooses edges to find the attacker. We give optimal strategies for the attacker and the inspector for a particular payoff function.

■ ThB13

13- Rivers

First–Order Methods for Structured and/or Conic Optimization – Part II

Cluster: Conic Programming

Invited Session

Chair: Robert Freund, Professor, MIT Sloan School of Mgmt., 77 Massachusetts Ave., Cambridge, MA, 02139, United States of America, rfreund@mit.edu

1 - An Extended Frank-Wolfe Method, with Applications to Low-Rank Matrix Completion

Paul Grigas, MIT Operations Research Center, 77 Massachusetts Ave., Cambridge, MA, 02139, United States of America, pgrigas@mit.edu, Robert Freund, Rahul Mazumder

We present an extension of the Frank-Wolfe method that is designed to induce near-optimal solutions on low-dimensional faces of the feasible region. We present computational guarantees for the method that trade off efficiency in computing near-optimal solutions with upper bounds on the dimension of minimal faces of iterates. We apply our method to the matrix completion problem, where low-dimensional faces correspond to low-rank matrices. We discuss practical implementation issues and present computational results for large-scale low-rank matrix completion problems that demonstrate its effectiveness. We demonstrate significant speed-ups in computing low-rank near-optimal solutions.

2 - Composite Conditional Gradient with Stochastic Approximation

Zaid Harchaoui, Researcher, NYU and Inria, NYU. CIMS, 715 Broadway, New York, NY, 10003, United States of America, zaid.harchaoui@inria.fr

We introduce a composite conditional gradient algorithm with stochastic approximation for stochastic convex optimization with composite objectives. The proposed algorithm requires a stochastic first-order oracle and a stochastic linear minimization oracle, in contrast to usual stochastic first-order optimization algorithms in a proximal setting. We establish the theoretical rate of convergence of several variants of the algorithm. We present experimental results for large-scale machine learning applications.

3 - On The Primal - Dual Rate Relation Of Dual Block Coordinate Descent Methods

Yakov Vaisbourd, Technion, Technion City, Haifa, 32000, Israel, yakov.vaisbourd@gmail.com, Ariel Shemtov, Luba Tetruashvili, Amir Beck

We consider the problem of minimizing the sum of a strongly convex function and several general extended valued convex functions. We establish a relation between the primal and the dual sequences that provide the rate of convergence of the primal sequence for any given convergence result on the dual sequence. We demonstrate the applicability of such methods for the TV denoising problem.

■ ThB14

14- Traders

Optimization under Uncertainty

Cluster: Stochastic Optimization

Invited Session

Chair: Alois Pichler, NTNU, Norway, Trondheim, Norway, Alois.Pichler@univie.ac.at

1 - Distributionally Robust Multistage Stochastic Optimization

Alexander Shapiro, Professor, Georgia Tech, Atlanta, GA, United States of America, alex.shapiro@isye.gatech.edu

In this talk we consider static and dynamic approaches to formulations of distributionally robust multistage stochastic programming problems. In particular we discuss decomposability and time consistency of such formulations and its relation to risk averse stochastic programming.

2 - Multistage Stochastic Convex Programs with a Random Number of Stages: Modelling and Solution Methods

Vincent Guigues, Prof, FGV, 190 Praia de Botafogo, Botafogo, Rio de Janeiro, RJ, 22250-900, Brazil, vguigues@fgv.br

We show how to write dynamic programming equations for risk-averse multistage stochastic convex programs with a random number of stages. This formulation allows us to solve these problems using decomposition methods such as SDDP. We study the convergence of various variants of these decomposition methods. In particular, we will consider inexact decomposition methods where all subproblems are solved with a bounded error.

■ ThB15

15- Chartiers

Optimization Software and Applications in Julia

Cluster: Implementations and Software

Invited Session

Chair: Miles Lubin, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-149, Cambridge, MA, 02139, United States of America, mlubin@mit.edu

1 - Convex Optimization in Julia

Madeleine Udell, Stanford University, udell@stanford.edu, David Zeng, Jenny Hong, Steven Diamond, Karanveer Mohan, Stephen Boyd

Convex.jl is a convex optimization modeling framework in Julia. Convex.jl translates problems from a user-friendly functional language into an abstract syntax tree describing the problem. This concise representation of the global structure of the problem allows Convex.jl to infer whether the problem complies with the rules of disciplined convex programming (DCP), and to pass the problem to a suitable solver. Convex.jl uses the MathProgBase abstraction for solver-independent mathematical optimization, enabling users to seamlessly switch between multiple backend solvers. We will give an overview of how Convex.jl works, and demonstrate its use in a few advanced applications.

2 - Calling Nonlinear and MINLP Solvers from Julia: Interfaces, Formats, Expression Trees and AD Tools

Tony Kelman, University of California - Berkeley, Berkeley, CA, kelman@berkeley.edu

While canonical interfaces for LP's are largely standardized across different solvers and programming languages, this is not the case for nonlinear or mixed-integer nonlinear optimization. Two existing tools in this area are the AMPL Solver Library and the COIN-OR Optimization Services project. We will discuss technical challenges and performance tradeoffs in using these tools from the Julia language, which is uniquely able to be simultaneously high-level, high-performance, user-friendly, and provide efficient interfaces to widely used optimization libraries. The JuliaOpt organization and the MathProgBase set of protocols present new levels of interoperability between solvers and different styles of optimization modeling environments.

3 - Robust Inventory Routing for the Real World: Using Julia, JuMP and JuMPeR

Joel Tay, Operations Research Center, MIT, 77 Massachusetts Ave, Bldg. E40-149, Cambridge, MA, 02139, United States of America, joeltay@mit.edu, Dimitris Bertsimas, Swati Gupta

We propose an efficient formulation for the finite horizon inventory routing problem with uncertain demand. While current stochastic optimization techniques do not scale well, we present a model implemented in Julia, using JuMP and JuMPeR (a JuMP extension for Robust Optimization) with Gurobi, with very promising computational results. We will share our experience developing this model in Julia and scaling it to problems of real-world size.

■ ThB16

16- Sterlings 1

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Eduardo Uchoa, Universidade Federal Fluminense, Escola de Engenharia, Rua Passo da Pàtria, 156, Niteroi, RJ, 24210, Brazil, eduardo.uchoa@gmail.com

1 - Symmetric Linear Programming Formulations for Minimum Cut with Applications to TSP

Robert Carr, Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM, United States of America, bobcarr@swcp.com, Benjamin Moseley, Giuseppe Lancia

We introduce new symmetric LP relaxations for minimum cut problems. Our relaxations give optimal and approximate solutions when the input is a Hamiltonian cycle. We show that this leads to one of two interesting results. In one case, these LPs always give optimal and near optimal solutions, and then they would be the smallest known symmetric LPs for the problems considered. Otherwise, these LP formulations give strictly better LP relaxations for the traveling salesman problem than the subtour relaxation.

2 - Big Improvements in Exact Algorithms for Vehicle Routing Problems

Eduardo Uchoa, Universidade Federal Fluminense, Escola de Engenharia, Rua Passo da Patria, 156, Niteroi, RJ, 24210, Brazil, eduardo.uchoa@gmail.com, Marcus Poggi

The best recent CVRP algorithms combine cut and column generation. This talk reviews those algorithms, highlighting the contributions in Baldacci, Christofides, Mingozzi (2008), Baldacci, Mingozzi , Roberti (2011), Ropke (2012), and Contardo, Martinelli (2014). It also presents the developments in Pecin et al. (2014), where a very sophisticated branch-cut-and-price using the limited memory technique could solve instances with more 300 customers. Improved results on other classical VRP variants are also mentioned.

3 - Construction and Improvement Heuristics for Vehicle Routing with Flexible Delivery Locations

Markus Frey, Technische Universitaet München, Arcisstrafle 21, Munich, Germany, markus.frey@tum.de, Alexander Doege, Daniel Gartner

In this paper, we study the problem of routing vehicles with flexible delivery locations and time points (VRPFLTP). We provide a Mixed-Integer Programming (MIP) formulation of the problem and develop construction and improvement heuristics to solve it. Instances are generated by the well-known Solomon test instances and extended to fit to our problem. In a thorough computational analysis, we evaluate computation times as well as the utility of flexible delivery locations. Our computational study reveals that the MIP fails to solve even small problems. However, our heuristic algorithm demonstrates relatively fast computation times and shows the economic potential of location flexibility.

■ ThB17

17- Sterlings 2

Uncertainty in Games

Cluster: Game Theory

Invited Session

Chair: Reshef Meir, Cambridge, Massachusetts, reshef24@gmail.com

1 - Learning Cooperative Games

Yair Zick, Postdoc, Carnegie-Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, yairzick@gmail.com, Maria Balcan, Ariel Procaccia

This paper explores a PAC (probably approximately correct) learning model in cooperative games. Specifically, we are given m random samples of coalitions and their values, taken from some unknown cooperative game; can we predict the values of unseen coalitions? We study the PAC learnability of several well-known classes of cooperative games, such as network flow games, threshold task games, and induced subgraph games. We also establish a novel connection between PAC learnability and core stability: for games that are efficiently learnable, it is possible to find payoff divisions that are likely to be stable using a polynomial number of samples.

2 - Reconstructing Preferences and Priorities from Opaque Transactions

Avrim Blum, Professor, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, avrim@cs.cmu.edu

Suppose you can observe who wins (but not the bids) in a repeated auction, plus participate yourself. Can you reconstruct buyers' distributions? How about for a repeated combinatorial auction: can you learn buyers' preferences and the seller's mechanism? In this talk I will discuss algorithms for both of these problems, with connections to decision-list learning in learning theory and Kaplan-Meier estimators in medical statistics. This is joint work with Yishay Mansour and Jamie Morgenstern.

3 - Simultaneous Abstraction and Equilibrium Finding in Games

Tuomas Sandholm, Professor, CMU, 9205 Gates-Hillman Center, Pittsburgh, PA, 15213, United States of America, sandholm@cs.cmu.edu, Noam Brown

The leading approach to large imperfect-information games is finding an equilibrium in an abstraction. We introduce a method that enables actions to be added to the abstraction during equilibrium finding — to points that the computed strategies deem important — while provably not needing to restart the equilibrium finding. The strategies improve as quickly as equilibrium finding in coarse abstractions, and converge to better solutions than equilibrium finding in fine-grained abstractions.

■ ThB18

18- Sterlings 3

Nonlinear Optimization and Applications

Cluster: Nonlinear Programming

Invited Session

Chair: Hande Benson, LeBow College of Business, Drexel University, Philadelphia, PA, 19104, United States of America, hvb22@drexel.edu

1 - Cubic Regularization in Quasi-Newton Methods

Hande Benson, LeBow College of Business, Drexel University, Philadelphia, PA, 19104, United States of America, hvb22@drexel.edu, David Shanno

Regularization techniques have been used to help existing algorithms solve "difficult" nonlinear optimization problems. Just over the last decade, regularization has been proposed as a remedy to handle equality constraints, equilibrium constraints, and other sources of nonconvexity, to bound Lagrange multipliers, to identify infeasible problems. In this talk, we will focus on the application of cubic regularization in the context of quasi-Newton methods.

2 - Numerical Optimization Applied to Space-Related Problems

Robert Vanderbei, Princeton University, 209 Sherrerd Hall, Princeton, NJ, 08544, United States of America, rvdb@princeton.edu

I will describe two "space related" optimization problems. The first is the design of telescopes that can achieve unprecendentedly high-contrast making it possible to directly image Earth-like extra-solar planets. The second application is to use optimization to find new, interesting, and often exotic solutions to the n-body problem. Finding such orbits could inform us as to what type of exoplanetary systems might exist around other nearby stars. In these two applications, I will explain the physics to make the optimization problem clear and then I will show some of the results we have been able to find using state-of-the-art numerical optimization algorithms.

3 - Blessing of Massive Scale: Multitask Optimization Total Cardinality Constraint

Ethan X. Fang, Princeton University, ORFE Sherrerd Hall, Charlton Street, Princeton, NJ, 08544, United States of America, xingyuan@princeton.edu, Han Liu, Mengdi Wang

We propose a novel framework for estimating of large-scale spatial graphical models with a total cardinality constraint. This work has two major contributions. (i) We minimize the summation of massive amounts of localized loss functions coupled by a global cardinality constraint. Theoretically, we show that the computational accuracy of our algorithm increases when the problem scale increases. Thus we see a bless of massive scale. We rigorously characterize the diminishing rate of the duality gap. (ii) In Gaussian or Ising graph estimation, we justify the obtained graph estimator achieves the minimax optimal rate of convergence under weak assumptions. We provide a through numerical investigation using both simulated and fMRI data.

■ ThB19

19- Ft. Pitt

Computational Sustainability

Cluster: Constraint Programming

Invited Session

Chair: Bistra Dilkina, Georgia Institute of Technology, Klaus Bldg 1304, Atlanta, GA, 30332-0765, United States of America, bdilkina@cc.gatech.edu

1 - Leveraging Moral-Motivation for Green Behavior Change in Networks

Gwen Spencer, Smith College, 180 Pleasant Street, Apt 306, Easthampton, MA, 01027, United States of America, gwenspencer@gmail.com

When spread models from behavioral economics are considered, optimal seeding of networks looks strongly different from the high-exposure/maximization-of-submodular-functions paradigm. We discuss several interesting byproducts of studying a model from environmental economics that describes when individuals will choose to engage in personally-costly provision for environmental quality. The optimal seeding problem is very hard (and slow in practice), but we discover a compelling prediction of network clustering, as well as a mechanism-design-oriented view of objective formulation in the management of landscape-scale natural systems under piecemeal management by risk/cost-averse local decision makers.

2 - Joint Mobilization and Planning for Large-Scale Evacuations

Pascal Van Hentenryck, Professor, NICTA/ANU, Australia, pvh@nicta.com.au, Victor Pillac, Caroline Even

Large-scale evacuations require authorities to decide and stage evacuation routes, mobilize resources, and issue evacuation orders under strict time constraints. These decisions must consider both the capacity of the road network and the evolution of the threat (e.g., a bushfire or a flood). This paper proposes, for the first time, an optimization model that jointly optimizes the mobilization and evacuation planning, taking into account the behavioural response of evacuees and the allocation of resources for communicating and implementing evacuation orders.

3 - Optimization Approaches for Robust Conservation Planning

Bistra Dilkina, Georgia Institute of Technology, Klaus Bldg 1304, Atlanta, GA, 30332-0765, United States of America, bdilkina@cc.gatech.edu

In the face of human development and climate change, it is important that wildlife conservation plans for protecting landscape connectivity exhibit certain level of robustness. We formalize this as a node-weighted bi-criteria network design problem with connectivity requirements on the number of disjoint paths between pairs of nodes. In contrast to previous work on survivable network design minimizing cost, our goal is to optimize the quality of the selected paths within a specified budget. We provide a MILP encoding, as well as a hybrid local search, based on solving small MIPs in the context of a large neighborhood search.

■ ThB20

20- Smithfield

Nonsmooth and Sparse Optimization with Applications

Cluster: Nonsmooth Optimization

Invited Session

Chair: Yuesheng Xu, Mathematics and Scientific Computation, Sun Yat-sen University, Guangzhou, China, yxu06@syr.edu

1 - Wavelet Inpainting with Sparse Regularization

Lixin Shen, Professor, Syracuse University, Mathematics, Syracuse, NY, United States of America, lshen03@syr.edu

In this talk we proposed a constrained inpainting model to recover an image from its incomplete and/or inaccurate wavelet coefficients. The objective function of the proposed model uses the ℓ_0 norm to promote the sparsity of the resulting image in a tight framelet system. A fixed-point proximity algorithm was developed to solve the model. Our numerical experiments show that the proposed model and the related fixed-point algorithm can recover images with much higher quality in terms of the PSNR values and visual quality of the restored images than the models based on the ℓ_1 norm and the total variation.

2 - Nonconvex Relaxation for Photon-Limited Sparse Optimization

Lasith Adhikari, Graduate Student, University of California, Merced, 5200 Lake Rd, Merced, Ca, 95343, United States of America, ladhikari@ucmerced.edu, Roummel Marcia

Critical to accurate reconstruction of sparse signals from low-dimensional Poisson observations is the solution of nonlinear optimization problems that promote sparse solutions. In this talk, we propose nonconvex regularizers to penalize the negative Poisson log-likelihood function in sparsity recovery problems in photon-limited imaging. We validate the effectiveness of the proposed approach by solving problems from image deblurring and fluorescence molecular tomography.

3 - Solving Linearly Constrained Convex Optimization Problems with Coupled Objective Functions

Cui Ying, PhD Student, Department of Mathematics, NUS, Department of Mathematics, NUS, Block S17, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, cuiying@nus.edu.sg, Xudong Li, Defeng Sun, Kim-Chuan Toh

In this talk, we present an augmented Lagrangian framework for solving large scale linearly constrained convex optimization problems with coupled objective functions. In order to achieve fast convergence for the method, we introduce an inexact accelerated block coordinate descent (ABCD) algorithm to deal with the inner subproblems. Numerical results show that our proposed algorithm is efficient and robust.

■ ThB21

21-Birmingham

Constrained and Parallel Derivative-Free Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Rommel Regis, Associate Professor, Saint Joseph's University, Department of Mathematics, 5600 City Avenue, Philadelphia, PA, 19131, United States of America, rregis@sju.edu

1 - A Derivative-Free Optimizer with Locally Convexified Constraints for Nonlinear Programming

Florian Augustin, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, fmaugust@mit.edu, Youssef Marzouk

We present a derivative free trust-region framework for solving nonlinear constrained optimization problems. The algorithm is based on minimum Frobenius norm models for the objective function and the constraints. We handle the constraints by adding a convex offset, the inner boundary path, to the constraint approximations. Additionally, we propose a noise detection feature that indicates inaccurate objective function and constraint evaluations. We close with numerical examples demonstrating the efficiency of the algorithm.

2 - Optimizing Agricultural Fertilizer Application using Derivative-Free Methods

Anahita Hassanzadeh, The Climate Corporation, 201 3rd Street #1100, San Francisco, CA, 94103, United States of America, anahita@climate.com

Fertilizer optimization is a key component of precision agriculture. The type, amount and timing of fertilizers applied to a field directly affect the yield, profitability and the environment. In this talk, we focus on optimizing the timing and amount of fertilizer applications with the goal of maximizing the expected revenue, which in turn depends on the expected yield. Given the complex system of natural processes involved, an analytic formula that captures the fertilizer-yield relationship is not available. We present our formulation of this problem as a constrained black-box optimization problem and use the DFO solver to solve it. We show our computational results on the performance comparison of this solver with several alternatives.

3 - Globalizing Local Search using Parallel Hybrid Derivative-Free Optimization

Scott Pope, SAS Institute, 100 SAS Campus Dr, Cary, NC, United States of America, Scott.Pope@sas.com, Joshua Griffin

We present potential enhancements to a SAS high performance procedure for black-box derivative-free optimization. We outline strategies to improve performance in a parallel hybrid environment by using global search algorithms to guide and coordinate multiple instances of local search routines. In particular we explore how these ideas can be used with DIRECT, a method for global Lipschitzian optimization, and Nelder-Mead, a method for simplex based optimization.

■ ThB22

22- Heinz

Variational Analysis in Stability of Variational Systems

Cluster: Variational Analysis

Invited Session

Chair: Nghia Tran, Oakland University, 2200 N. Squirrel, Rochester, MI, 48309, United States of America, nttran@oakland.edu

1 - Characterizations of Tilt Stability in Nonlinear Programming Under Weakest Qualification Conditions

Helmut Gfrerer, Johannes Kepler University, Altenbergerstrasse 69, Linz, 4040, Austria, Helmut.Gfrerer@jku.at, Boris Mordukhovich

Tilt-stability locally ensures the single-valuedness and Lipschitz continuity of local minimizers with respect to small linear perturbations of the objective function. It can be characterized via the positive definiteness of the second-order subdifferential of the objective. In this talk we characterize tilt-stability in classical nonlinear programming (NLP) with smooth data by means of first-order and second-order derivatives of the problem functions at the reference point. We provide sufficient and necessary conditions for tilt-stability under some qualification conditions on the constraints which are weaker than the Mangasarian-Fromovitz constraint qualification.

2 - Full Stability for Parametric Variational Systems

Nghia Tran, Oakland University, 2200 N. Squirrel, Rochester, MN, 48309, United States of America, nttran@oakland.edu

We introduce new notions of Lipschitzian and Holderian full stability of solutions to general parametric variational systems described via partial subdifferential and normal cone mappings acting in Hilbert spaces. These notions are closely related to local strong maximal monotonicity of associated set-valued mappings. Based on advanced tools of variational analysis and generalized differentiation, we derive verifiable characterizations of these full stability notions via some positive-definiteness conditions involving second-order constructions of variational analysis. The general results obtained are specified for important classes of variational inequalities and variational conditions in both finite and infinite dimensions.

3 - Normal and Nondegenerate Forms of Optimality Conditions for Control Problems with State Constraints

Fernando Fontes, Professor, Universidade do Porto, Systec-ISR, Faculdade de Engenharia, Universidade do Porto, Porto, 4200-465, Portugal, faf@fe.up.pt

For some optimal control problems with pathwise state constraints, the standard forms of the maximum principle may not provide adequate information to select minimizers. This is the case when the scalar multiplier associated with the objective function is equal to zero — the abnormal case, or when the set of multipliers is such that any admissible candidate to solution satisfies the optimality conditions — the degenerate case. We discuss recently proposed stronger forms of optimality conditions, valid under suitable constraint qualifications, that do not allow abnormal or degenerate multipliers.

■ ThB23

23- Allegheny

Graphs of Polyhedra

Cluster: Combinatorial Optimization

Invited Session

Chair: Timothy Yusun, Simon Fraser University, Faculty of Science, 250-13450 102 Ave, Surrey, BC, V3T0A3, Canada, tyusun@sfu.ca

1 - Edges vs Circuits: a Hierarchy of Diameters in Polyhedra

Steffen Borgwardt, Visiting Assistant Professor, UC Davis, Department of Mathematics, Davis, CA, 95616, United States of America, sborgwardt@math.ucdavis.edu, Jesus De Loera, Elisabeth Finhold

The study of the graph diameter of polyhedra is a classical open problem in the theory of linear optimization. We introduce a vast hierarchy of generalizations to the notion of graph diameter. This hierarchy provides some interesting lower bounds for the usual graph diameter. After explaining the structure of the hierarchy and discussing these bounds, we focus on explaining the differences and similarities among the many diameter notions of our hierarchy. Finally, we fully characterize the hierarchy in dimension two. It collapses into fewer categories, for which we exhibit the ranges of values that can be realized as diameters.

2 - The Circuit Diameter of the Klee-Walkup Polyhedron

Timothy Yusun, Simon Fraser University, Faculty of Science, 250-13450 102 Ave, Surrey, BC, V3T0A3, Canada, tyusun@sfu.ca, Tamon Stephen

Consider a variant of the edge-vertex diameter of a polyhedron where each step travels in a circuit direction, i.e. the direction of any edge or potential edges under a translation of the facets, and is maximal subject to feasibility. This is the notion of circuit diameter. In this talk we investigate the circuit diameter of the Klee-Walkup polyhedron, a critical example in the study of polyhedron diameters.

3 - A Mihalisin-Klee Theorem for Fans

Walter Morris, George Mason University, Departmentr of Mathematical Sciences, 4400 University Drive, Fairfax, VA, 22030, United States of America, wmorris@gmu.edu, Rachel Locke

The Mihalisin - Klee Theorem states that an orientation of a 3-polytopal graph is induced by an affine function on some 3-polytope realizing the graph if the orientation is acyclic, has a unique source and a unique sink, and admits three independent monotone paths from the source to the sink. We replace the requirement that the orientation is acyclic with the assumption that it has no directed cycle contained in a face of the orientation, and show that such orientations are induced by 3-dimensional fans.

■ ThB24

24- Benedum

MINLP: Non-Standard Approaches and Applications II

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Victor Blanco, Universidad de Granada, Facultad de CC Economicas, Granada, Spain, vblanco@ugr.es

1 - Continuous Location under the Effect of Refraction

Justo Puerto, Universidad de Sevilla, Dpto. Estadística e Investigación Operat, Sevilla, Spain, puerto@us.es, Victor Blanco, Diego Ponce

In this paper we address the problem of locating a new facility on a d-dimensional space when the distance measure is different at each one of the sides of a given hyperplane H. We relate this problem with the physical phenomenon of refraction, and extend it to any finite dimensional space and different distances at each one of the sides of any hyperplane. Extensive computational experiments run in Gurobi are reported in order to show the effectiveness of the approach. Some extensions of these models are also presented.

2 - Alternative Methods in Linear Regression

Victor Blanco, Universidad de Granada, Facultad de CC Economicas, Granada, Spain, vblanco@ugr.es, Roman Salmeròn, Justo Puerto

We present a wide family of new methods to estimate the coefficients of a linear body to fit a given sample of data. We combine the choice of alternative distance-based residuals with ordered weighted averaging aggregation operators for the residuals. The general optimization problem for those methods is formulated as MINLP. Special cases of the general family are analyzed. For instance, we analyze the classical methods that fit such a general shape, and also the cases when the residuals are measured with block or lp norms. Several experiments, coded in R, have been performed to show the differences and similarities between the new estimations.

3 - A Mixed-Integer Nonlinear Program for the Design and Dispatch of Hybrid Power Generation Systems

Alexandra Newman, Professor, Colorado School of Mines, Department of Mechanical Engineering, Golden, CO, 80401, United States of America, anewman@mines.edu, Johanna Stark Goodman, Sven Leyffer, Mike Scioletti

Renewable energy technologies, combined with battery storage and diesel generators, form hybrid energy systems capable of independently powering locations isolated from the grid. We present an optimization model to determine design and dispatch strategies while minimizing costs, and adhering to constraints on load, power supply, and the way in which the technologies operate. Procurement and some dispatch decisions are integer, while battery behavior introduces nonlinearities. We demonstrate how to solve large instances using linear approximations.

■ ThB25

25- Board Room

Distributed Algorithms for Optimization and Control in Power Systems

Cluster: Optimization in Energy Systems

Invited Session

Chair: Uday Shanbhag, 353 Leonhard Building, University Park, PA, 16802, United States of America, udaybag@engr.psu.edu

1 - Privacy-Preserving Distributed Optimization and Control of the Smart Grid

Minghui Zhu, Penn State University, muz16@psu.edu

Distributed optimization and control has emerged as a major tool to manage distributed energy resources in the smart grid. Distributed optimization and control necessitates information sharing among spatially distributed entities. This raises the important issue that private information of legitimate entities could be leaked to malicious entities. In this talk, we will present our recent results on distributed optimization and control algorithms which have provable information-theoretic privacy guarantees.

2 - Synchronous and Asynchronous ADMM Algorithms for Eigenvalue Estimation in Power Systems

Aranya Chakrabortty, Assistant Professor, NC State University, 1791 Varsity Drive, Raleigh, NC, 27695, United States of America, achakra2@ncsu.edu, Jianhua Zhang

We propose a distributed-ADMM algorithm for estimating eigenvalues arising from the swing dynamics of power systems. The estimators, distributed over a wide-area communication network, receive real-time dynamic data from the sensors following a disturbance, run local estimation loops using a Prony algorithm, and communicate their estimates with each other through a given communication graph to execute a distributed consensus, and thereby converge to a global estimate iteratively. We impose a probability distribution model for the communication delays between the estimators, and implement two strategies of distributed averaging to cope with the asynchrony resulting from the delays.

3 - A Distributed Approach for Optimal Power Flow Problem

Hesam Ahmadi, ahmadi.hesam@gmail.com, Uday Shanbhag

In this paper, an ADMM-based distributed approach for the solution of the DC optimal power flow problem is presented. We consider a dual formulation and utilize the structure to develop a distributed scheme. We show that the resulting sequence of primal and dual iterates are provably convergent. Preliminary numerics are provided.

■ ThB27

27- Duquesne Room

The Knapsack Problem

Cluster: Combinatorial Optimization

Invited Session

Chair: James Orlin, MIT, E62-570, Cambridge, MA, 02139, United States of America, jorlin@mit.edu

1 - Approximation of the Knapsack Problem with Conflicts

Ulrich Pferschy, University of Graz, pferschy@uni-graz.at, Joachim Schauer

We consider the classical 0-1 Knapsack Problem with additional conflict restrictions on pairs of items, which state that for certain pairs of items at most one item can be contained in any feasible solution. This can also be seen as a Maximum Weight Independent Set Problem with an additional budget constraint. The conflicts between items can be represented by a conflict graph. We will give an overview on the status of approximability for different graph classes. In particular, we will describe an FPTAS for graphs of bounded treewidth and for (weakly) chordal graphs and a PTAS for planar graphs. Also modular and clique decompositions will be discussed leading to an FPTAS for certain graph classes characterized by forbidden subgraphs.

2 - Approximation Algorithms for the Incremental Knapsack Problem

Chun Ye, Columbia University, 500 W120th St., Mudd 315, New York, NY, 10027, United States of America, cy2214@columbia.edu, Daniel Bienstock, Jay Sethuraman

We consider an incremental version of the knapsack problem (IK), where we wish to find an optimal packing of items in a knapsack whose capacity grows weakly as a function of time. We will first show that the problem is strongly NP-hard. We will then discuss a constant factor approximation algorithm for IK, under mild restrictions on the growth rate of the knapsack capacity, and a PTAS for IK when the time horizon T is a constant. Both of our algorithms uses ideas from disjunctive programming.

3 - Faster Approximation Schemes for Knapsack Problems

James Orlin, MIT, E62-570, Cambridge, MA, 02139, United States of America, jorlin@mit.edu, David Rhee

We present a new fully polynomial time approximation scheme (FPTAS) for each of several variants of knapsack problems. These schemes obtain solutions that are guaranteed to have a relative error of at most epsilon, and run in time polynomial in the data and in 1/epsilon. We have developed FPTASes that are faster than the previous best FPTASes for each of the following problems: (1) the nonlinear knapsack problem, (2) the unbounded knapsack problem, (3) the 0-1 knapsack problem, (4) the integer knapsack problem, and (5) the knapsack problem with generalized upper bounds.

■ ThB28

28- Liberty Room

Convexification Techniques in Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Akshay Gupte, Clemson University, Department of Mathematical Sciences, Clemson, SC, 29634, United States of America, agupte@clemson.edu

1 - Semidefinite Approximations of the Copositive Cone

Sergio Camelo, Universidad de los Andes, Cra 1 N∫ 18A- 12, Depto de Matematicas, Bogota, Colombia, sa.camelo38@uniandes.edu.co, Mauricio Velasco

Linear optimization over the copositive cone C (i.e. the cone of quadratic forms which are nonnegative in the positive orthant) has applications in mixed quadratic optimization and in combinatorial optimization. Although convex, this problem is not tractable directly. A construction due to A. Barvinok and E. Veomett and independently J.B. Laserre produces a sequence $(P_k)_{k\in\mathbb{N}}$ of nested spectrahedral cones that contain C. In this work we study this hierarchy and compare its empirical performance with that of the polyhedral and SOS approximations to the copositive cone. In particular, we show results on its practical performance for estimating the clique number of a graph. These results are joint work with M. Velasco.

2 - Valid Inequalities for Separable Concave Constraints

Cong Han Lim, University of Wisconsin - Madison, 3009 University Ave, Apt #305, Madison, United States of America, conghan@cs.wisc.edu, James Luedtke, Jeff Linderoth

Relaxations of separable concave constraints are usually obtained by considering each constraint individually and using the secant obtained from the bounds of the associated variable. We propose a technique for incorporating other variables to tighten the relaxation. In particular, we study the convex hull of a simple set with separable concave constraints, and we derive classes of strong valid inequalities. Computational results for concave-cost flow networks will be presented.

3 - New Multi-Commodity Flow Formulations for the Generalized Pooling Problem

Fabian Rigterink, University of Newcastle, University Drive, Callaghan NSW, 2308, Australia, fabian.rigterink@uon.edu.au, Martin Savelsbergh, Thomas Kalinowski, Natashia Boland

The generalized pooling problem (GPP) is a nonconvex nonlinear programming problem with numerous applications. Much attention has been paid to reformulating the GPP such that linear relaxations provide better bounds. We present new multi-commodity flow formulations for the GPP and discuss their strengths. We conclude the talk by presenting a variation of the GPP arising in mining and solve a real-world blending problem for the port of Newcastle (Australia), the world's largest coal export port.

■ ThB29

29- Commonwealth 1

Solution of Variational Inequalities and Applications

Cluster: Nonsmooth Optimization

Invited Session

Chair: Xiaoming Yuan, Hong Kong Baptist University, Kowloon Tong, HongKong, China, xmyuan@hkbu.edu.hk

1 - A Variational-Inequality-Based Algorithm for Locating Multiple Interactive Facilities under Gauge

Jianlin Jiang, Dr., Nanjing University of Aeronautics and Astronautics, 29 Jiangjun Rd., Jiangning District, Nanjing, China, jiangjianlin_nju@163.com

This talk considers a generalized multi-source Weber problem (GMWP), i.e., locating multiple facilities under gauge with considering the locational constraints on facilities and the interactive transportations between facilities. With a variational inequality approach (VI) proposed for solving the involved constrained multi-facility subproblems in the location phase, a new variational-inequality-based location-allocation heuristic algorithm is presented for GVWP. The convergence of the VI approach and the location-allocation algorithm is proved under mild assumptions. Some preliminary numerical results are reported which verify the efficiency of the proposed variational-inequality-based heuristic algorithm.

2 - Lp Regularization for Optimization over Permutation Matrices

Bo Jiang, Dr., Nanjing Normal University, No. 1 Wenyuan Road, Qixia District, Nanjing, China, jiangbo@njnu.edu.cn, Zaiwen Wen, Ya-Feng Liu

Optimization problem over permutation matrices has wide applications in graph matching, computer manufacturing, scheduling, etc. In this talk, we shall consider the Lp regularization for optimization over permutation matrices. Some theoretic properties of the Lp regularization will be introduced and analyzed. The preliminary numerical results on QAPLIB instances show that our Lp regularization approach is very promising for the quadratic assignment problem.

3 - A General Inertial Proximal Point Method for Mixed Variational Inequality Problem

Junfeng Yang, Dr., Nanjing University, 22 Hankou Road, Nanjing, 210093, China, jfyang@nju.edu.cn, Caihua Chen, Shiqian Ma

We first propose a general inertial proximal point method for the mixed variational inequality problem. Under certain conditions, we are able to establish the global convergence and a $o(1/k)$ convergence rate result of the proposed method. By applying the proposed method to linearized augmented Lagrangian method and the linearized alternating direction method of multipliers, we obtain their inertial versions whose global convergence are guaranteed. We also demonstrate the effect of the inertial extrapolation step via experimental results on the compressive principal component pursuit problem.

■ ThB30

30- Commonwealth 2

Approximation and Online Algorithms

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Andreas Karrenbauer, Max Planck Institute for Informatics, Campus E1 4, Saarbruecken, 66123, Germany, andreas.karrenbauer@mpi-inf.mpg.de

1 - Improved Algorithms for Vertex Cover with Hard Capacities on Multigraphs and Hypergraphs

Wang Chi Cheung, PhD Student, MIT, 77 Massachusetts Ave, Cambridge, MA, 02139, United States of America, wangchi@mit.edu, Michel Goemans, Chiu-wai Wong

We consider the minimum unweighted vertex cover problem with hard capacity constraints. Given a graph, the objective is to find a smallest multiset of vertices covering all edges; each selected vertex only covers a limited number of incident edges, and the number of available copies of each vertex is bounded. This problem was first studied by Saha and Khuller (ICALP 2012), who proposed 38 and max{6f, 65} approximation algorithms for multigraphs and f-hypergraphs respectively. We improve these ratios to 2.155 and 2f respectively. Our algorithms consist of a two-step process, each based on rounding an appropriate LP. For multigraphs, the analysis in the second step relies on identifying a matching structure within any extreme point solution.

2 - Almost Tight Approximation Results for Biclique Cover and Partition

Andreas Karrenbauer, Max Planck Institute for Informatics, Campus E1 4, Saarbruecken, 66123, Germany, andreas.karrenbauer@mpi-inf.mpg.de, Parinya Chalermsook, Sandy Heydrich, Eugenia Holm

We consider the problems of covering/partitioning the edgeset of a bipartite graph with/into a minimum number of complete bipartite subgraphs (a.k.a. bicliques). We show that both problems are as hard to approximate as Coloring. By exploiting properties of graph products, we obtain lower bounds for the approximation guarantee of poly-time algorithms, which grow almost linearly in the number of nodes. We thereby raise the previous best lower bound for Minimum Biclique Cover by a power of 3. The improvement for Minimum Biclique Partition is even more significant, where only APX-hardness was known before. Furthermore, we provide sub-linear approximation factors, which almost closes the remaining gap between upper and lower bounds.

3 - Cutting Plane Methods for Minimax Distributionally Robust Optimization

Huifu Xu, University of Southampton, Highfield, Southampton, United Kingdom, h.xu@soton.ac.uk

Slater-type conditions have been widely used for solving minmax distributionally robust optimization (DRP) problems. This paper introduces new weaker and more verifiable conditions based on a stability result due to Shapiro for minimax DRP with matrix moment constraints. Moreover, it introduces a randomization scheme for approximating the semi-infinite constraints and relates approach to discretization of the ambiguity set defined through moments. Cutting plane methods have been proposed for both minimax DRO with distretized ambiguity set and its Lagrange dual. Convergence analysis has been presented for the approximation schemes in terms of the optimal value, optimal solutions and stationary points.

Thursday, 1:10pm - 2:40pm

■ ThC01

01- Grand 1

Complementarity/Variational Inequality IV

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Jong Shi Pang, University of Southern California, 3715 McClintock Avenue, GER 240, Los Angeles, CA, 90089, United States of America, jongship@usc.edu

1 - Modeling Dynamic Traffic Assignment Problems using Differential Complementarity Systems

Xuegang Ban, Associate Professor, Rensselaer Polytechnic Institute, 110 8th St, JEC 4034 CEE RPI, Troy, NY, 12180, United States of America, banx@rpi.edu, Jong Shi Pang, Rui Ma

Dynamic Traffic Assignment (DTA) problems are one of the most challenging problems in transportation science. Extensive research has been done in the past on modeling/solving DTA problems, mainly in the discrete-time domain. This talk concerns about modeling and solving DTA in the continuous-time domain, which enables the investigation of some fundamental issues of DTA such as discretization, convergence, etc. By applying a recent mathematical paradigm, named Differential Complementarity Systems (DCS), it is shown that DCS can better capture the key characteristics of continuous-time DTA and allows more rigorously modeling of DTA. Challenges and future research directions of using DCS to model and solve DTA will also be presented.

2 - A Stochastic Multi-Agent Optimization Model for Energy Infrastructure System Planning

Yueyue Fan, Associate Professor, University of California-Davis, Dept. of Civil and Environmental Eng., Davis, CA, 95616, United States of America, yyfan@ucdavis.edu, Zhaomiao Guo

This paper presents a stochastic multi-agent optimization model that supports renewable energy infrastructure planning under uncertainty. The interdependence between different stakeholders in the system is captured in an energy supply chain network, where new entrants of renewable investors compete among themselves and with existing generators for natural resources, transmission capacities, and demand markets. Solution algorithm based on variational inequalities and stochastic decomposition is designed to overcome computational difficulties. A real-world application based on Sacramento Municipal Utility District (SMUD) power network is implemented to draw engineering and policy insights.

3 - Computing B-Stationary Points of Nonsmooth DC Programs

Jong Shi Pang, University of Southern California, 3715 McClintock Avenue, GER 240, Los Angeles, CA, 90089, United States of America, jongship@usc.edu, Meisam Razaviyayn, Alberth Alvarado

This paper studies a nonsmooth, difference-of-convex (dc) minimization problem. The contributions of this paper are: (i) clarify several kinds of stationary solutions and their relations; (ii) develop and establish the convergence of a novel algorithm for computing a d-stationary solution of a problem with a convex feasible set that is arguably the sharpest kind among the various stationary solutions; (iii) extend the algorithm in several directions including: a randomized choice of the subproblems that could help the practical convergence of the algorithm, a distributed penalty approach for problems whose objective functions are sums of dc functions, and problems with a specially structured (nonconvex) dc constraint.

■ ThC02

02- Grand 2

Optimization Under Uncertainty in Electric and Gas Energy Systems

Cluster: Optimization in Energy Systems

Invited Session

Chair: Andy Sun, Assistant Professor, Georgia Institute of Technology, 765 Ferst Drive, Room 444 Groseclose Bld., Atlanta, GA, 30332, United States of America, andy.sun@isye.gatech.edu

1 - Two-stage Distributionally Robust Unit Commitment With Extended Linear Decision Rules

Ruiwei Jiang, Assistant Professor, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, 48109, United States of America, ruiweijiang@email.arizona.edu, Jianhui Wang, Yuanyuan Guo

It can be challenging to accurately estimate the joint probability distribution of the renewable energy. In this talk, based on a small amount of marginal historical data, we propose a two-stage distributionally robust unit commitment model that considers a set of plausible probability distributions. Numerical results show that this approach is less conservative than the classical robust unit commitment models and more computationally tractable by using extended linear decision rules.

2 - Reinforcement of Gas Transportation Networks with Uncertain Demands

Frederic Babonneau, Vice president, Ordecsys, Rue du Gothard, 5, Chéne-Bourg, Switzerland, fbabonneau@gmail.com

The present work extends an earlier paper of Babonneau, Nesterov and Vial on the reinforcement of gas transmission networks to include uncertainty on the demands via robust optimization, fixed costs and commercial restrictions on pipe sizes. The model in continuous variables is SOCP and combines reinforcement and robust constraints. The handling of discrete variables leads to a mixed SOCP. Numerical results will be presented.

3 - Sub-Hourly Optimization Effects in the European Power Grid under Deep Renewable Energy Integration

Ignacio Aravena, PhD Student, Center for Operations Research and Econometrics, UC Louvain, Voie du Roman Pays 34, Louvain-la-Neuve, 1348, Belgium, ignacio.aravena@uclouvain.be, Antony Papavasiliou

Day-ahead electricity markets are usually managed using an hourly resolution which masks the sub-hourly fluctuations of renewable supply. We present a detailed model of the European day-ahead market (hourly resolution), and compare its performance against deterministic and stochastic unit commitment (hourly and 15' minutes resolution) in terms of real-time operation cost, estimated using a Monte Carlo scheme and a 15' real-time model. Numerical experiments are conducted using a detailed instance of Central Western European system.

■ ThC03

03- Grand 3

Combinatorial Optimization: Beyond Linear Relaxations

Cluster: Combinatorial Optimization

Invited Session

Chair: Jose Correa, Universidad de Chile, Republica 701, Santiago, Chile, correa@uchile.cl

1 - Easy or Selfish Scheduling on Related Machines

Neil Olver, VU University Amsterdam & CWI, De Boelelaan 1105, 1081 HV, Amsterdam, Netherlands, olver@cwi.nl, Jose Correa, Mona Rahn, Guido Schaefer

We consider a question about the weighted sum of completion times on related machines, one with two equivalent formulations. What is the approximation ratio of the natural greedy list scheduling heuristic? Alternatively, what is the worst-case price of anarchy of the scheduling game in this setting? This is well understood for the case of unrelated machines, but we will discuss an approach (based on convex relaxations) for obtaining better bounds in the related machines case.

2 - Approximating ATSP by Relaxing Connectivity

Ola Svensson, EPFL, EPFL-IC, Building INJ (INJ112), Lausanne, 1015, Switzerland, ola.svensson@epfl.ch

A long standing open problem is to understand whether the asymmetric traveling salesman problem admits a constant factor approximation algorithm. We propose a new approach for tackling this problem and show that our approach yields a constant factor approximation algorithm when restricted to shortest path metrics of node-weighted graphs. The considered case is more general than the directed analog of the special case of the symmetric traveling salesman problem for which there were recent improvements on Christofides' algorithm.

3 - Strong LP Formulations for Scheduling Splittable Jobs on Unrelated Machines

Jose Verschae, Assistant Professor, Ponthifical Catholic University of Chile, Av Vicuña 4860, Las Condes, Santiago, RM, 7580641, Chile, jverschae@uc.cl, Leen Stougie, Ola Svensson, Alberto Marchetti-Spaccamela, Jannik Matuschke, Victor Verdugo, Jose Correa

We consider a natural scheduling problem where we need to assign jobs to machines in order to minimize the makespan. In our variant jobs may be split into parts, where each part can be (simultaneously) processed on different machines. Splitting jobs helps balancing the load, but this is not for free: each part requires a setup time, increasing the processing requirement of the job. I will introduce the problem and present approximation algorithms based on the rounding of different types of relaxations. Our main result is a (1+f)-approximation algorithm, where f~1.618 is the golden ratio. This ratio is best possible for the relaxation used. On the negative side we show that the problem is NP-hard to approximate within a factor of 1.582.

■ ThC04

04- Grand 4

Nonnegative Matrix Factorization and Related Topics I

Cluster: Conic Programming

Invited Session

Chair: Nicolas Gillis, Rue de Houdain 9, Mons, 7000, Belgium, nicolasgillis@gmail.com

Co-Chair: Stephen A. Vavasis, University of Waterloo, 200 University Avenue W., Waterloo, ON, N2L 3G1, Canada, vavasis@uwaterloo.ca

1 - Fast Hierarchical Nonnegative Matrix Factorization for Clustering

Da Kuang, Postdoctoral Researcher, Georgia Institute of Technology, 2042 Oak Park Cir NE, Atlanta, GA, 30324, United States of America, kdmaths@gmail.com

I will present fast algorithms for Rank-2 nonnegative matrix factorization (NMF) for large-scale clustering. The algorithms are architecture-aware, incurring contiguous memory access for higher throughput. Recursively applying Rank-2 NMF to a data set generates a hierarchy of clusters efficiently, which can be easily converted into a flat partitioning as well. Examples on topic modeling, hyperspectral imaging, and community detection will be used to demonstrate the significantly improved efficiency of our algorithms.

2 - Near-Separable Non-Negative Matrix Factorization with l1 and Bregman Loss Functions

Abhishek Kumar, IBM T.J. Watson Research Center, Yorktown Heights, NY, 10598, United States of America, abhishek@umiacs.umd.edu, Vikas Sindhwani

Recently, a family of tractable NMF algorithms have been proposed under the assumption that the data matrix satisfies a separability condition. Geometrically, this condition reformulates the NMF problem as that of finding the extreme rays of the conical hull of a finite set of vectors. We propose separable NMF algorithms with l1 loss and Bregman divergences that extend the conical hull procedures proposed in our earlier work (Kumar et al., 2013). On foreground-background separation problems in computer vision, the proposed near-separable NMF algorithms match the performance of Robust PCA, considered state of the art on these problems, with an order of magnitude faster training time. We also demonstrate applications in exemplar selection.

3 - Constrained Orthogonal Nonnegative Matrix Factorization

Vamsi Potluru, Comcast Cable, 1110 Vermont Ave NW, Washington, DC, 20005, United States of America, vamsi_potluru@cable.comcast.com

Nonnegative matrix factorization has been successfully applied to a wide range of applications such as document clustering, hyperspectral image analysis, and speech enhancement. Additional constraints such as sparsity, orthogonality have been imposed to incorporate prior domain knowledge. We present a new model for imposing orthogonal constraints which are better aligned with user-defined requirements. Empirical evaluations are shown on real-world datasets.

■ ThC05

05- Kings Garden 1

Recent Advances in Computational Optimization II

Cluster: Nonlinear Programming

Invited Session

Chair: William Hager, Professor, University of Florida, Department of Mathematics, Gainesville, FL, 32611, United States of America, hager@ufl.edu

Co-Chair: Hongchao Zhang, Professor, Louisiana State University, Baton Rouge, LA, United States of America, hozhang@math.lsu.edu

1 - SQP methods for Optimization Problems in Simulation and Control

Philip E. Gill, UC San Diego, Department of Mathematics, La Jolla, CA, 92039-0112, United States of America, pgill@ucsd.edu, Michael Saunders, Elizabeth Wong

Many practical problems in simulation and control require the solution of a sequence of related nonlinear optimization problem with a large, but sometimes dense constraint Jacobian. In this context, we consider some aspects of the formulation and analysis of "fast" sequential quadratic programming (SQP) methods.

2 - An Augmented Lagrangian Filter Method for Nonlinear Optimization

Sven Leyffer, Argonne National Laboratory, 9700 South Cass Ave, Argonne, IL, United States of America, leyffer@mcs.anl.gov

We present a new augmented Lagrangian filter method that incorporates a new augmented Lagrangian filter to control the accuracy of the approximate minimization of the augmented Lagrangian. We show that the method converges globally, and present numerical results.

3 - Sparse Techniques for Polyhedral Projection

William Hager, Professor, University of Florida, Department of Mathematics, Gainesville, FL, 32611, United States of America, hager@ufl.edu, Hongchao Zhang

An efficient algorithm is developed for projecting a point onto a polyhedron. The algorithm solves a dual version of the primal projection problem and then uses the relationship between the primal and dual to recover the projection. The techniques exploit sparsity. SpaRSA (Sparse Reconstruction by Separable Approximation) is used to approximately identify active constraints in the polyhedron, and the Dual Active Set Algorithm (DASA) is used to compute a high precision solution. A new Q-linear convergence result is established for SpaRSA. An algorithmic framework is developed for combining SpaRSA with an asymptotically preferred algorithm such as DASA. It is shown that only the preferred algorithm is executed asymptotically.

■ ThC06

06- Kings Garden 2

Geometry and MINLP

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Jon Lee, University of Michigan, jonxlee@umich.edu

1 - Optimal Double McCormick for Trilinear Monomials

Emily Speakman, University of Michigan, Ann Arbor, MI, United States of America, eespeakm@umich.edu, Jon Lee

When using the standard McCormick inequalities iteratively to linearize trilinear monomials, there is a choice of which variables to group first. In this talk, we explore the effect of this choice on the feasible regions of the resulting linear relaxations. By computing the 4-dimensional volumes of appropriate polytopes (which are dependent on the upper and lower bounds of the variables), we describe the optimal way to perform this double McCormick linearization.

2 - Mixed-integer Optimization of Unconstrained Polynomials

Sönke Behrends, PhD Student, Georg-August-Universitaet Goettingen, Lotzestr. 16-18, Goettingen, 37083, Germany, s.behrends@math.uni-goettingen.de, Anita Schöbel

Given a multivariate polynomial, we consider the problem to find its unconstrained mixed-integer minimum. As the general case is undecidable, we rely on a sufficient condition for the existence of minimizers: If the leading form is positive definite, we give explicit bounds on the norm of all minimizers, which improves on a result on continuous minimizers from the literature. The problem can then be solved using branch and bound - which requires lower bounds. To this end we introduce a class of underestimators; choosing the best underestimator can be recast as a sum-of-squares program. Using ideas from real algebraic geometry, the lower bound can be further tightened. For the integer case, we present results on random instances.

3 - Advances in Mixed-Integer Black Box Optimization with Expensive Function Evaluation

Giacomo Nannicini, Prof., SUTD, Singapore University of Technology and Design, 8 Somapah Road, Singapore, Singapore, nannicini@sutd.edu.sg, Alberto Costa

We study the problem of optimizing an unknown function given as an oracle (black box) over a mixed-integer set. We assume that the oracle is expensive to evaluate. Our approach is based on the Radial Basis Function method originally proposed by Gutmann (2001). Our main methodological contributions are an approach to exploit a noisy but less expensive oracle to accelerate convergence to the optimum of the exact oracle, and an automatic model selection phase during the optimization process. Numerical experiments show that these contributions significantly improve the performance of the algorithm on a test set of continuous and mixed-integer nonlinear unconstrained problems. Our implementation is available under Revised BSD license.

■ ThC07

07- Kings Garden 3

Mathematical Programming in Data Science II

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Dolores Romero Morales, Professor in Operations Research, Copenhagen Business School, PorcelÊnshaven 16 A, Copenhagen, Denmark, drm.eco@cbs.dk

1 - Rectangular Maps for Graph Visualization: A Mixed Integer Nonlinear Approach

Vanesa Guerrero Lozano, University of Seville, C/ Tarfia s/n, 41012, Sevilla, 41012, Spain, vguerrero@us.es, Emilio Carrizosa, Dolores Romero Morales

In this talk we address the problem of representing a weighted graph by means of a rectangular map, i.e., a subdivision of a rectangle into rectangular portions, so that each portion is associated with one individual, the areas of the portions reflect the weights, and portions adjacencies reflect adjacencies in the binary relation. This visualization problem is formulated as a three-objective Mixed Integer Nonlinear problem. Our numerical results demonstrate that is is possible to provide a collection of rectangular maps with different tradeoffs between an accurate representation of the weights by areas versus an accurate representation of the relation by adjacencies.

2 - Exact Mathematical Programming Formulations for Balanced Tree Partitioning Problems

Onur Seref, Virginia Tech, Pamplin 1007, Blacksburg, VA, 24061, United States of America, seref@vt.edu, Paul Brooks

In this paper, we study variations of the Balanced Tree Partitioning problem. Some versions of this problem such as the k-Balanced Tree Partitioning problem are known to be NP-hard. Although there are a number of studies on approximation algorithms, exact mathematical programming formulations are not well understood. We introduce compact exact mixed integer programming formulations to solve different variations of the Balanced Tree Partitioning problem. We explore the effect of different sets of constraints on our formulations and provide comparative computational results among our formulations as well as other exact formulations and approximation algorithms.

3 - Network-based Data Mining via Clique Relaxations

Eugene Lykhovyd, Texas A&M University, TAMU-3131, College Station, TX, 77843, United States of America, lykhovyd@tamu.edu, Austin Buchanan, Sergiy Butenko

We discuss network-based data mining techniques that utilize clique relaxation models in networks. In particular, the methodology is applied to analyze bitcoin transaction data.

■ ThC08

08- Kings Garden 4

(Co)Sparsity in Tomography and Inverse Problems

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Andreas Tillmann, TU Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, tillmann@mathematik.tu-darmstadt.de

1 - Cosparse Image Recovery from Few Tomographic Projections

Stefania Petra, Heidelberg University, Speyerer Strafle 6, HCI, Heidelberg, 69115, Germany, petra@math.uni-heidelberg.de

We consider the reconstruction problem in discrete tomography from the viewpoint of compressed sensing (CS). We present an average-case relation between image cosparsity and sufficient number of tomographic measurements for exact recovery similar to the settings in CS, and observe a phase transition known in CS, but not established for the tomographic set-up. In addition, we present a large-scale total-variation minimization approach for reconstructing 3D solid bodies composed of few different materials from a limited number of tomographic projections.

2 - Verification of Exact Solutions in Compressed Sensing with Application to CT

Christian Kruschel, University of Goettingen, Lotzestr. 16-18, Goettingen, 37083, Germany, Christian.Kruschel@mathematik.uni-goettingen.de, Jakob S. Jörgensen, Dirk A. Lorenz

Compressed Sensing techniques are promising for reducing measurements in several applications. However, considering computed tomography, theoretical results, based for example on the restricted isometry property or mutual coherence, deliver bad results for applying compressed sensing. In this talk, we analyze the applicability of compressed sensing to CT via their sufficient (and necessary) conditions. For that purpose we construct uniqueness tests for basis pursuit, anisotropic and isotropic total variation. Further we construct test instances which will be used for Monte Carlo experiments to empirically show that a phase transition in dependency of measurements and sparsity also exists for fan-beam CT applications.

3 - Sparse Signal Recovery from Nonlinear Measurements

Yonina Eldar, Technion, Techion City, Haifa, Israel, yonina@ee.technion.ac.il

We consider an extension of compressed sensing to nonlinear measurements. We present several optimality criteria for sparse recovery from nonlinear measurements and show that they can be used to develop efficient recovery algorithms. A special case that is of large interest in optics is phase retrieval, in which one needs to recover an image given only its Fourier transform magnitude. We consider conditions on the number of measurements needed for stable phase retrieval and show that surprisingly the results coincide with those obtained in the linear measurement setting (up to constants). We demonstrate our algorithms on a variety of problems in optical imaging.

■ ThC09

09- Kings Garden 5

Robust Optimization: Applications to Operations Management

Cluster: Robust Optimization

Invited Session

Chair: Chaithanya Bandi, Assistant Professor, Kellogg School of Management, Northwestern University, 2001 Sheridan Road, 566, Evanston, IL, 60208, United States of America, c-bandi@kellogg.northwestern.edu

1 - Increasing Supply Chain Robustness through Process Flexibility and Inventory

Yehua Wei, Duke University, 100 Fuqua Drive, P.O. Box 90120, Durham, NC, 27713, United States of America, yehua.wei@duke.edu, David Simchi-Levi, He Wang

We study a hybrid strategy that uses both process flexibility and inventory to mitigate risks of plant disruption. In this setting, a firm allocates inventory before disruption while facing demand uncertainties; and schedules its production after demand and disruption are realized. This problem is modeled as a two-stage robust optimization. We show that the robust optimization model can be formulated as a linear program and solved efficiently. Using analytical and numerical analysis, we study the impact of different flexibility designs on the firm's inventory decisions. Our analysis the impact of process flexibility on total inventory level; freedom in inventory placement; inventory allocation strategy.

2 - Simulation Optimization of Stochastic Systems via Robust Optimization

Nataly Youssef, MIT, 20 Palermo Street, Cambridge, MA, 02141, United States of America, youssefn@mit.edu, Dimitris Bertsimas

We propose a tractable approach for simulating and optimizing stochastic systems via robust optimization. Specifically, we model uncertainty via parameterized polyhedral sets inspired by probabilistic limit laws and characterized by variability parameters that control the degree of conservatism of the model. We then cast the fundamental performance analysis and risk minimization problems as robust optimization problems. We demonstrate the tractability and accuracy of our approach via applications from inventory management and portfolio optimization.

3 - Robust All Pay Auctions and Optimal Crowdsourcing

Chaithanya Bandi, Assistant Professor, Kellogg School of Management, Northwestern University, 2001 Sheridan Road, 566, Evanston, IL, 60208, United States of America, c-bandi@kellogg.northwestern.edu

In this talk, we present and analyze a model in which users select among, and subsequently compete in, a collection of contests offering various rewards. The objective is to capture the essential features of a crowdsourcing system, an environment in which diverse tasks are presented to a large community. We answer this question in the setting of incomplete information via All pay auctions and robust optimization.

ThC10

10- Kings Terrace

Risk Management Approaches in Engineering Applications

Cluster: Finance and Economics

Invited Session

Chair: Stan Uryasev, University of Florida, Gainesville, FL, 32611, United States of America, uryasev@ufl.edu

1 - Maximization of AUC and Buffered AUC in Classification

Matthew Norton, University of Florida, 2449 NW 93rd st, Gainesville, FL, 32606, United States of America, mdnorton@ufl.edu

We utilize a new concept, called Buffered Probability of Exceedance (bPOE), to introduce an alternative to the Area Under the Receiver Operating Characteristic Curve (AUC) performance metric called Buffered AUC (bAUC). Central is a new technique for optimization of bPOE, reducing it to convex, sometimes even linear, programming. We utilize bPOE to create the bAUC performance metric, showing it to be an intuitive counterpart to AUC that is much easier to optimize than AUC, specifically reducing to convex and linear programming. We use these properties to introduce the bAUC Efficiency Frontier, a concept that serves to partially resolve the ``incoherency” that arises when misclassification costs need be considered.

2 - CVaR Distance between Univariate Probability Distributions and Approximation Problems

Konstantin Pavlikov, University of Florida, 1350 N Poquito Road, Shalimar, FL, United States of America, kpavlikov@ufl.edu, Stan Uryasev

In this talk we define new distances between univariate probability distributions, based on the concept of the CVaR norm. We approximate a discrete distribution by another discrete distribution by minimizing new distances. We find: (i) optimal locations of atoms of the approximating distribution with fixed probabilities and (ii) optimal probabilities with a priori fixed approximating positions of atoms. These two steps are further combined in an iterative procedure for finding both atom locations and their probabilities. Numerical experiments show high efficiency of the proposed approach, solved with convex and linear programming.

3 - Buffered Probability of Exceedance for Multidimensional Random Variables

Alexander Mafusalov, University of Florida, 303 Weil Hall P.O. Box 116595, Gainesville, FL, 32611, United States of America, mafusalov@ufl.edu, Stan Uryasev

This paper introduces a new probabilistic characteristic called buffered probability of exceedance (bPOE). This characteristic is an extension of so-called buffered probability of failure and it is equal to one minus superdistribution function. Paper provides efficient calculation formulas for bPOE. bPOE is proved to be a closed quasi-convex and monotonic function of random variable. Minimization of the bPOE can be reduced to a convex program for a convex feasible region and to LP for a polyhedral feasible region. A family of bPOE minimization problems and family of the corresponding CVaR minimization problems share the same frontier of optimal solutions and optimal values.

ThC11

11- Brigade

Independent and Hitting Sets of Rectangles

Cluster: Combinatorial Optimization

Invited Session

Chair: Jose Soto, Assistant Professor, Universidad de Chile, Beauchef 851, Quinto Piso., Santiago, Chile, jsoto@dim.uchile.cl

1 - Approximation Algorithms for Independent Set/Hitting Set of Non-Piercing Rectangles via Local Search

Norbert Bus, PhD Student, Université Paris-Est, 2, Boulevard Blaise Pascal, Noisy-Le-Grand Cedex, 93126, France, busn@esiee.fr, Nabil Mustafa, Shashwat Garg, Saurabh Ray

Local search is a simple and powerful framework in the design of algorithms for combinatorial optimization problems. In this talk we will describe a local-search algorithm for approximating independent/hitting sets of non-piercing rectangles. Using local search Chan and Har-Peled (2009) gave a PTAS for calculating independent set of non-piercing rectangles, Mustafa and Ray (2010) gave the first PTAS for the minimum hitting set problem for disks. Although these techniques give arbitrarily good approximations, their running time is prohibitively large. Recently Bus et al. (2015) improved the method, achieving 8-approximation of independent set of non-piercing rectangles with (3,2)-local search. We describe the key elements of these results.

2 - Decomposition Techniques for Coloring and Independent Set of Rectangles

Parinya Chalermsook, MPII, Campus E1 4, Saarbrucken, 66123, Germany, parinya@mpi-inf.mpg.de

Given a collection of rectangles in the plane, we consider the following two questions: (i) Computing a maximum cardinality subset of pairwise non-overlapping rectangles and (ii) Bounding the chromatic number of a rectangle intersection graph in terms of its clique number. In this talk, I will discuss techniques that decompose any rectangle intersection graph into several “easy” subinstances (those “easy” instances are either perfect or degenerate graph.) This technique has been used in obtaining the following results: An O(log log n) approximation algorithm for the first problem, an O(w log w)-coloring for a broad class of input, and an O(w)-coloring for a relaxed problem where rectangles are allowed to shrink slightly.

3 - Independent and Hitting sets of Rectangles Intersecting a Diagonal Line

Jose Soto, Assistant Professor, Universidad de Chile, Beauchef 851, Quinto Piso., Santiago, Chile, jsoto@dim.uchile.cl, Jose Correa, Pablo Perez-Lantero, Laurent Feuilloley

Wegner conjectured in the 60s that the duality gap between the maximum independent set (MIS) and the minimum hitting set (MHS) of any set of axis-parallel rectangles is bounded by a constant. An interesting special case, that may be useful to tackle the general one, is the diagonal-intersecting case, in which all rectangles are intersected by a diagonal. We show that MIS in diagonal-intersecting sets is NP-complete. Then we derive an O(n^2)-time algorithm for the maximum weight independent set (MWIS) when, in addition the rectangles intersect below the diagonal. This implies a 2-approximation algorithm for MWIS on diagonal-intersecting families. Finally, we prove that for diagonal-intersecting sets the duality gap is between 2 and 4.

ThC12

12- Black Diamond

Stochastic Methods for Procurement with Auctions and Contracts

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Chefi Triki, Associate Prof., Sultan Qaboos University, Al Khoud, Muscat, 123, Oman, chefi.triki@unisalento.it

1 - A Solution Approach for WDP in Combinatorial Transportation Procurement Auctions under Uncertainty

Nabila Remli, Cirrelt, 2325 rue de la Terrasse, Quebec, Canada, nabila.remli@gmail.com, Monia Rekik, Issmail Elhallaoui

In combinatorial transportation auctions, shippers act as auctioneers who need to outsource a number of transportation services to external carriers. Carriers compete by submitting bids on packages of shippers’ requests. After receiving all carriers’ bids, the shipper solves the well-known winner determination problem (WDP) in order to determine winning bids. This paper considers the WDP in a context where shipment volumes are not known with certainty. A 2-stage robust formulation is proposed and solved using a constraint generation algorithm. Different accelerating procedures are proposed. Our experimental results show that these accelarting procedures considerably reduce computing times.

2 - Generating Bids in Combinatorial Auctions for the Truckload Procurement

Chefi Triki, Associate Prof., Sultan Qaboos University, Al Khoud, Muscat, 123, Oman, chefi.triki@unisalento.it

Combinatorial Auctions have shown to be very efficient in allocating resources to bidders. Even in the logistics sector several successful experiences of companies that have used CAs in order to procure their transportation needs and achieved remarkable cost savings. Carriers can also take advantage from participating in the e-markets by bidding on loads that reduce the truck empty movements in their transportation networks. The aim of the talk is to define a probabilistic optimization model for the bid generation and evaluation problem that integrates also the routing decision related to the carriers' fleet. Moreover, we develop two heuristic procedures in order to solve the BGP and test their performance on a set of test instances.

■ ThC13

13- Rivers

Mathematical Programming with Equilibrium Constraints

Cluster: Game Theory

Invited Session

Chair: Siddharth Barman, California Institute of Technology, 1200 E. California Blvd., MC 305-16, Pasadena, CA, 91125, United States of America, sid.barman@caltech.edu

1 - Polynomial-Time Complementary Pivot Algorithms for Market Equilibria

Jugal Garg, Max-Planck Institute for Informatics, MPI, Building Campus E1 4, Room 321, Saarbrücken, 66123, Germany, jugal.garg@gmail.com, Milind Sohoni, Ruta Mehta, Nisheeth Vishnoi

We consider the problem of computing market equilibria in the Fisher model for utility functions such as linear, spending constraint and perfect price-discrimination. In each case we start with a convex program that captures market equilibria, and in a systematic way, covert it into a linear complementary problem (LCP) formulation. To obtain a polynomial-time algorithm, we depart from previous approaches of pivoting on a single polyhedron associated with the LCP. Instead, we carefully construct a polynomial-length sequence of polyhedra, one containing the other, such that starting from an optimal solution to one allows us to obtain an optimal solution to the next in the sequence in a polynomial number of complementary pivot steps.

2 - Approximating Sparse Bilinear Programs via an Approximate Version of Caratheodory's Theorem

Siddharth Barman, California Institute of Technology, 1200 E. California Blvd., MC 305-16, Pasadena, CA, 91125, United States of America, sid.barman@caltech.edu

We present novel algorithmic applications of an approximate version of Caratheodory's theorem. This theorem establishes that, given a set of vectors X in R^d, for every vector in the convex hull of X there exists an \epsilon-close (under the p-norm, for 2<= p < \infty) vector that can be expressed as a convex combination of at most b vectors of X, where the bound b is independent of the dimension d. This theorem can be obtained by instantiating Maurey's empirical method (c.f. Pisier 1980/81 and Carl 1985). We use this approximate version of Caratheodory's theorem to develop efficient additive approximation algorithms for (i) sparse bilinear programs over the simplex, and (ii) Nash equilibria in a relevant class of two-player games.

3 - Faster First-Order Methods for Extensive-Form Game Solving

Christian Kroer, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, ckroer@cs.cmu.edu, Tuomas Sandholm, Fatma Kilinc-Karzan, Kevin Waugh

We investigate the application of first-order methods to computing a Nash equilibrium in two-player zero-sum extensive-form games. Many first-order methods rely on a measure of distance over the search space. For our setting, a natural measure is the dilated entropy function. We study this function on treeplexes, which are convex polytopes that encompass the strategy spaces of the players. We develop significantly stronger bounds on the associated strong convexity parameter. In terms of game solving, this considerably improves the convergence rate of several first-order methods. We instantiate both deterministic and stochastic first-order methods using our results, and experimentally show that our algorithms outperform prior algorithms.

■ ThC14

14- Traders

Cryptography, Game Theory and Bounded Rationality

Cluster: Game Theory

Invited Session

Chair: Rafael Pass, Associate Professor, Cornell University, 111 8th Avenue #302, NY, NY, 10011, United States of America, rafael@cs.cornell.edu

1 - The Truth Behind the Myth of the Folk Theorem

Lior Seeman, Cornell University, New York, NY, United States of America, lior.seeman@gmail.com, Rafael Pass

The complexity of finding a Nash equilibrium (NE) is a fundamental question at the interface of game theory and computer science. Our focus in this talk is on the complexity of finding a NE in repeated games. Earlier work by Borgs et al. [2010] suggests that this problem is computationally intractable, even if we only care about finding an ϵ-NE. But, if we take seriously the question of efficiently finding a NE, it must be because we have computationally-bounded players in mind. We show that if players are indeed computationally bounded (polynomial-time Turing machines), and we make some standard cryptographic hardness assumptions (the existence of public-key encryption), then there exists a polynomial-time algorithm for finding an ϵ-NE in repeated games.

2 - Analyzing Cut and Choose Protocols

Abhi Shelat, U of Virginia, 85 Engineer's Way, Charlottesville, VA, 22902, United States of America, abhi@virginia.edu

The technique of cut-and-choose enables constructing cryptographic protocols that are efficient and yet secure against malicious behavior. The basic idea is for one party to prepare a set of "puzzles," a subset of which a verifier audits and the rest of which the verifier requests solutions from the prover. In folklore discussions of this technique, the Prover and Verifier strategies for cut-and-choose are deterministic. In this talk, we use minmax to construct an optimal randomized strategy that leads to both theoretical and practical improvements for many applications such as secure 2-party computation. Joint observation with Y Huang, J Katz, and E Shi.

3 - Reasoning Cryptographically about Knowledge

Rafael Pass, Associate Professor, Cornell University, 111 8th Avenue #302, NY, NY, 10011, United States of America, rafael@cs.cornell.edu

Cryptographic notions of knowledge consider the knowledge obtained, or possessed, by computationally-bounded agents under adversarial conditions. In this talk, we will survey some recent cryptographically-inspired approaches for reasoning about agents' knowledge in the context of mechanism design, voting theory and weather forecasting.

■ ThC15

15- Chartiers

Massive Parallel Implementations of Optimization Software

Cluster: Implementations and Software

Invited Session

Chair: Thorsten KochProf. Dr., ZIB / TU Berlin, Takustr. 7, Berlin, 14195, Germany, koch@zib.de

1 - How to Run a Customized SCIP Solver on Supercomputers with Over 80,000 Cores

Yuji Shinano, Zuse Institute Berlin, Takustr. 7, 14195, Berlin, Germany, shinano@zib.de

SCIP is a framework for Constraint Integer Programming that enables us to develop a customized SCIP solver for a specific combinatorial optimization problem by writing user plugins. ParaSCIP and FiberSCIP are two parallel extensions of SCIP, and their libraries provide us a systematic way to parallelize the customized solver with little effort. Computational results of ParaSCIP for MIP solving show that the parallel version of a customized solver could potentially run on supercomputers with over 80,000 cores. In this talk, we will present a few success stories of obtaining optimal solutions for previously unsolved instances for Steiner Tree Problem and Resource Constrained Project Scheduling Problem.

2 - Advances in the CPLEX Distributed Solver

Laszlo Ladanyi, IBM, 11 Interlaken Rd, Lakeville, CT, United States of America, ladanyi@us.ibm.com, Daniel Junglas

We present some of the new ideas added to CPLEX's distributed solver along with computational analysis of the performance gained compared to the traditional shared memory solver.

3 - A Matrix Scheduling Heuristic to Disaster Restoration of Lifeline Networks

Akifumi Kira, Associate Professor, Institute of Mathematics for Industry, Kyushu University, 744 Motooka, Nishi-ku, Fukuoka city, 819-0395, Japan, kira@imi.kyushu-u.ac.jp, Katsuki Fujisawa, Hidenao Iwane, Hirokazu Anai

The establishment of scheduling techniques, for handling with precedence constraints and synchronized restoration with two or more teams, has become a very important issue. In this talk, we propose an indirect local search method using multiple lists, which succeeds to stamp out the so-called interdependence problem induced by the precedence and synchronization constraints. We have applied parallel computing techniques to this local search method and report numerical results on large-scale SMP servers.

■ ThC16

16- Sterlings 1

Risk Aversion in Routing Games

Cluster: Telecommunications and Networks

Invited Session

Chair: Evdokia Nikolova, University of Texas at Austin, 1616 Guadalupe St, Austin, TX, United States of America, nikolova@austin.utexas.edu

1 - Risk Sensitivity of Price of Anarchy under Uncertainty

Georgios Piliouras, Assistant Professor, Singapore University of Technology and Design, 8 Somapah Road, Singapore, Singapore, georgios.piliouras@gmail.com, Jeff S. Shamma, Evdokia Nikolova

In algorithmic game theory, price of anarchy studies efficiency loss in decentralized environments. Robust optimization explores tradeoffs between optimality and robustness for single agent decision making under uncertainty. We establish connections between the two and prove tight performance guarantees for distributed systems in uncertain environments. We present applications of this framework to novel variants of atomic congestion games with uncertain costs, for which we provide tight performance bounds under a wide range of risk attitudes. Our results establish that the individual's attitude towards uncertainty has a critical effect on system performance and should therefore be a subject of close and systematic investigation.

2 - Improving Selfish Routing for Heterogeneous Risk-Averse Users

Thanasis Lianeas, University of Texas at Austin, 1616 Guadalupe Street, Austin, United States of America, tlianeas@mail.ntua.gr

We investigate how and to which extent one can exploit risk-aversion and modify the perceived latencies of the players so that the Price of Anarchy (PoA) is improved. To provide a simple and general model, we adopt g-modifiable routing games where the perceived cost of edge e for a player of aversion type a_i can increase from l_e(x) to (1+a_i*g_e)l_e(x), for some selected g_e in [0,g]. For g-modifiable games in parallel-links, we show how to (efficiently) compute a set of g-bounded latency modifications so that the PoA of the resulting game improves significantly as g increases. We prove that our PoA analysis is tight. In a generalizing step, we let ||(g_e)_e||_p <= g for any p-norm and provide tight PoA results for the generalized model.

3 - The Burden of Risk Aversion in Mean-Risk Selfish Routing

Evdokia Nikolova, University of Texas at Austin, 1616 Guadalupe St, Austin, TX, United States of America, nikolova@austin.utexas.edu, Nicolas Stier-Moses

Considering congestion games with uncertain delays, we compute the inefficiency introduced in network routing by risk-averse agents. We define the price of risk aversion (PRA) as the worst-case ratio of the social cost at a risk-averse Wardrop equilibrium to that where agents are risk-neutral. For networks with general delay functions and a single source-sink pair, we show that the PRA depends linearly on the agents' risk tolerance and on the degree of variability present in the network. In contrast to the price of anarchy, in general the PRA increases when the network gets larger but it does not depend on the shape of the delay functions.

■ ThC17

17- Sterlings 2

Numerical Methods for Nonlinear Optimization III

Cluster: Nonlinear Programming

Invited Session

Chair: Ya-Xiang Yuan, Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Zhong Guan Cun Donglu 55, Haidian, Beijing, 100190, China, yyx@lsec.cc.ac.cn

1 - A New Fully Polynomial Time Approximation Scheme for Interval Subset Sum Problem

Yu-Hong Dai, Prof., AMSS,Chinese Academy of Sciences, No. 55, ZhongGuanCunDongLu, Beijing, 100190, China, dyh@lsec.cc.ac.cn

The interval subset sum problem (ISSP) is a generalization of the well-known subset sum problem. We show that the ISSP is relatively easy to solve compared to the 0-1 knapsack problem. We also identify several subclasses of the ISSP which are polynomial time solvable (with high probability). Then we propose a new fully polynomial time approximation scheme for solving the general ISSP problem. To the best of our knowledge, the proposed scheme has almost the same time complexity but a significantly lower space complexity compared to the best known scheme. Both the correctness and efficiency of the proposed scheme are validated by numerical simulations. This is a joint work with Rui Diao and Yafeng Liu.

2 - Augmented Lagrangian Methods for Nonlinear Programming with Possible Infeasibility

Jefferson Melo, PhD, Federal University of Goias, Campus Samambaia, Goiania, Go, 74001-970, Brazil, jefferson.ufg@gmail.com, Max Goncalves, Leandro Prudente

We consider a nonlinear programming problem for which the constraint set may be infeasible. We propose an algorithm based on general augmented Lagrangian functions and analyze its convergence properties. We show that, in a finite number of iterations, the algorithm stops detecting the infeasibility of the problem or finds an approximate feasible/optimal solution. We present some numerical experiments showing the applicability of the algorithm.

3 - A Primal-Dual Merit Function with Primal-Proximity Term

Wenwen Zhou, SAS Institute Inc., 100 SAS Campus Drive., Cary, NC, 27513, United States of America, Wenwen.Zhou@sas.com, Joshua Griffin

Classical augmented Lagrangian methods perform line-searches using only the primal variables. The dual variables are subsequently updated, but without a merit function. More recent approaches seek to perform a unified primal-dual line-search by adding a dual proximity term to the merit function, penalizing distance from the primal-multiplier estimates. An unfortunate consequence is that the dual variables necessarily grow large when the problem is infeasible or the overall constraint violation does not decrease proportionally to the penalty parameter. In this talk we show that the addition of a primal-proximity term can counterbalance this effect and additionally greatly improving convergence rates to feasible points.

■ ThC18

18- Sterlings 3

Nonconvex, Non-Lipschitz, and Sparse Optimization III

Cluster: Nonlinear Programming

Invited Session

Chair: Xiaojun Chen, Professor, The Hong Kong Polytechnic University, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, xiaojun.chen@polyu.edu.hk

1 - Regularized Mathematical Programs with Stochastic Equilibrium Constraints: Estimating Demand Models

Hailin Sun, Nanjing University of Science and Technology, School of Economics and Management, Nanjing, 210094, China, hlsun@njust.edu.cn, Xiaojun Chen, Roger Wets

The article considers a particular class of optimization problems involving set-valued stochastic equilibrium constraints. We develop a solution procedure that relies on regularization and sample average approximation scheme for the equilibrium constraints. Convergence is obtained by relying on the graphical convergence of the approximated equilibrium constraints. The problem of estimating the characteristics of a demand model serves both as motivation and illustration of the regularization and sampling procedure.

2 - Distributionally Robust Bidding Model of Power-Controllable Lighting System in Electricity Market

Yanfang Zhang, Minzu University of China,
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yfzhang@lsec.cc.ac.cn

This paper investigates a distributionally robust optimization based bidding model for simultaneously participating in day-ahead and real-time electricity markets. The optimal bidding model of LED lighting system is proposed. By the CVaR constraints, the conditional expectation minimization model under the ellipsoidal moment uncertainty is reformulated to be a worst-case expectation minimization problem. Moreover, a solvable semi-definite program (SDP) is presented to relax the moment uncertainty problems and determine the optimal bids. Simulation results illustrate the feasibility and effectiveness of the proposed model and solution method.

3 - Efficient Global or Hybrid Projected Gradient Algorithm for 10 and Convex Constrained Optimization

Fengmin Xu, Associate Professor, Xi'an Jiaotong University,
School of Mathematics and Statistics, Xi'an, 710049, China,
fengminxu@mail.xjtu.edu.cn

Sparse optimization has attracted increasing attentions in numerous areas. This paper considers a special class of L_0 constrained optimization, which involves box constraints and a singly linear constraint. An efficient approach is provided for calculating the projection over the feasibility set. Then we present several types of projected gradient methods for the special class of L_0 constrained optimization. Global convergence of the methods are established under suitable assumptions. The implementation on signal recovery and enhanced indexation demonstrate that the proposed projected gradient methods are efficient in terms of both solution quality and speed. A Joint work with Yu-Hong Dai, Zhihua Zhao and Zongben Xu.

ThC19

19- Ft. Pitt

Constraint Programming

Cluster: Constraint Programming

Invited Session

Chair: K. Subramani, Professor, West Virginia University, 749 ESB, CSEE,, WVU, Morgantown, WV, 26506, United States of America, k.subramani@mail.wvu.edu

1 - Numerical Methods for Solving Discrete Conditional Moment Problems

Mariya Naumova, Rutgers University, 100 Rockafeller Rd,
Piscataway, NJ, 08854, United States of America,
mariya.v.naumova@gmail.com

We propose a framework for bounding the expectation of discrete random variables. The bounds are based on the knowledge of some of the power moments as well as conditional moments of the random variables. The discrete conditional moment bounding problems are formulated as LP's with special structures and can be solved using Dantzig-Wolfe decomposition by the used of the Discrete Moment Problem (DMP). We illustrate our method with numerical examples.

2 - Quantifying Linear Programs and Implications

K. Subramani, Professor, West Virginia University, 749 ESB, CSEE,
WVU, Morgantown, WV, 26506, United States of America,
k.subramani@mail.wvu.edu, Pavlos Eirinakis

A Quantified Linear Program (QLP) consists of a set of linear inequalities and a quantifier string, in which each universal variable is bounded. A Quantified Linear Implication (QLI) is an inclusion query over two polyhedral sets with respect to a specified quantifier string. QLPs and QLIs offer a rich modelling language for several important real-life applications, such as reactive systems and real-time schedulers. We provide a brief presentation of applications and recent theoretical developments in the areas of QLPs and QLIs. We discuss the computational complexities of various QLP and QLI classes and show that for each class of the PH, there exists a QLI that is complete for that class.

3 - Solving Large Scale Linear Programming Problems

Parvin Khosravi, Shahed University, Department of Applied
Mathematics, Shahed University, Tehran, Iran,
parvin_khosraviii@yahoo.com, Saeid Akbari

The aim of this paper is to find an exact 2-norm solution to the dual linear programming problem and to generate an exact solution to the primal programming problems. The Newton method is proposed for solving linear programs with 1000000 of variables. We also compare the differences between Goldstein and Wolf conditions in order to find step size in each iterations. We give encouraging comparative test results with MATLAB.

ThC20

20- Smithfield

Stochastic Methods

Cluster: Nonsmooth Optimization

Invited Session

Chair: Zhimin Peng, PhD Student, University of California - Los Angeles, Mentone Ave, Apt 212, Los Angeles, CA, 90034, United States of America, zhimin.peng@math.ucla.edu

1 - Randomization in Online Stochastic Gradient-Free Optimization

Ilnura Usmanova, MIPT, Pervomayskaya, 28a, Dolgoprudnii,
141700, Russia, ilnura94@gmail.com, Ekaterina Krymova, Fedor
Fedorenko

We consider the problem of stochastic online optimization with noisy dual-point zero-order oracle in the convex and strongly convex cases. We also show how to choose optimal proximal structure in mirror decent depending on the optimisation set. We establish that the optimal choice of randomization for the estimation of the gradient is a uniform distribution on the unit Euclidean sphere. We also obtain a bound on the noise level, such that pseudo-regret bounds have same forms(up to a factor), as if there wasn't any noise.

2 - Asynchronous Parallel Stochastic Algorithms and Applications

Zhimin Peng, PhD Student, University of California, Los Angeles,
3777 Mentone Ave, Apt 212, Los Angeles, CA, 90034, United
States of America, zhimin.peng@math.ucla.edu, Wotao Yin,
Ming Yan, Yangyang Xu

In this talk, we will give some convergences result on the asynchronous parallel stochastic algorithm with bounded delay to solve fixed point problems. Weak convergence result is provided for alpha-averaged operator, and linear convergence rate is obtained for strongly monotone operator. Special cases of these operators are used to solve problems related to solving linear systems, minimizing convex smooth functions, and minimizing convex nonsmooth functions. We provide some numerical results for these applications.

ThC21

21-Birmingham

Recent Advances in Derivative-Free Optimization III: New Algorithms

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Zaikun Zhang, Dr., F 325, IRIT, 2 rue Camichel, Toulouse, 31071, France, zaikunzhang@gmail.com

1 - Locating All Minima of a Smooth Function without Access to its Derivatives

Jeffrey Larson, Dr., Argonne National Laboratory, 9700 S Cass
Ave, 240-1151, Argonne, IL, United States of America,
jmlarson@anl.gov, Stefan Wild

We present a multistart algorithm for identifying all local minima of a bound-constrained derivative-free optimization problem. With relatively weak assumptions on the function, our method almost surely identifies all local minima while starting only a finite number of local optimization runs. We extend our method by developing rules for pausing local optimization runs, e.g., as they approach previously identified minima or other runs, while ensuring that the initial theoretic underpinnings of the algorithm still hold. We present a parallel implementation of our method that uses concurrent evaluations of the objective functions to more efficiently search the domain.

2 - A New Model-Based Trust-Region Derivative-Free Algorithm for Inequality Constrained Optimization

Mathilde Peyrega, PhD Student, Ecole Polytechnique Montreal,
6-4600 rue saint dominique, Montreal, QC, H2T1T5, Canada,
mathilde.peyrega@polymtl.ca, Sebastien Le Digabel,
Andrew R. Conn, Charles Audet

We present a new model-based trust-region algorithm to treat derivative-free optimization (DFO) problems with bounds and inequality constraints. We consider inequality constraints which can be evaluated at infeasible points, but for which their derivatives are not available. The basic models use interpolation and regression. We discuss the management of sample sets, choice of models and approaches to handling constraints, as well as numerical aspects.

3 - Direct Search based on Probabilistic Descent

Clément Royer, ENSEEIHT-IRIT, 2 rue Charles Camichel, Toulouse CEDEX 7, 31071, France, clement.royer@enseeiht.fr, Serge Gratton, Luis Nunes Vicente, Zaikun Zhang

We propose and analyze a general direct-search framework where the directions are randomly generated so that at least one is descent with a certain probability. We first establish that the algorithm converges almost surely to a first-order stationary point. Compared to the deterministic case, we improve the worst-case complexity bound on the number of function evaluations (now established with overwhelming probability). Finally, we confirm the theoretical findings by showing that this technique significantly reduces the numerical cost of the method.

■ ThC22

22- Heinz

Stability in Structured Optimization: Current Trends and Modern Applications

Cluster: Variational Analysis

Invited Session

Chair: Guoyin Li, University of New South Wales, Department of Applied Mathematics, University of New South Wales,Kensington, Sydney, NS, 2052, Australia, g.li@unsw.edu.au

1 - Symmetry, Invariance and Criticality

Andrew Eberhard, RMIT University, Mathematical and Geospatial Sciences, Melbourne, Australia, andy.eb@rmit.edu.au, V era Roshchina

The aim of this talk is to summarise, relate and generalise a range of results in nonsmooth, and predominantly nonconvex analysis, that exploit the symmetry of underlying problems. Results of this kind date back to the work of Palais on the principle of symmetric criticality but there are more recent results that can be placed in a similar framework that revolves around the application of groups of symmetries. Some new results of this kind will be discussed including one involving monotone operators. We will also discuss some applications.

2 - Uniformly Sequentially Regular Functions with Applications to Semi-Infinite Vector Optimization

Chuong Thai Doan, Dr., University of New South Wales, Sydney NSW 2052, Sydney, Australia, chuongthaidoan@gmail.com, Do Sang Kim

We establish new verifiable conditions for the feasible set of a nonsmooth semi-infinite vector optimization problem in Banach spaces to have the normal regularity (that is, the coincidence of the Fréchet normal cone and the Mordukhovich normal one) at a given point. Also, both the Fréchet normal cone and the Mordukhovich normal one to the considered set are then computed via active constraint multipliers and limiting subdifferentials of the involved constraints. In order to achieve such goals, two classes of nonsmooth functions are introduced and exploited. Finally, the obtained results are applied to provide optimality conditions and study sensitivity analysis in semi-infinite vector optimization problems.

■ ThC23

23- Allegheny

MIP Formulations for Difficult Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Alexander Tesch, Zuse Institute Berlin (ZIB), Takustrafle 7, Berlin, 14195, Germany, tesch@zib.de

1 - A Branch-and-Cut Approach to the General Offset Assignment Problem

Sven Mallach, Universitaet zu Koeln, Albertus-Magnus-Platz, Koeln, 50923, Germany, mallach@informatik.uni-koeln.de

The general offset assignment problem is a hard combinatorial problem that arises in compilers for special-purpose processors, such as, e.g. digital signal processors. It is of crucial importance for the machine code size and execution speed of the resulting programs. The problem can be decomposed into a Hamiltonian cycle and a min-cost flow problem, and with some effort, we obtain a linear integer programming formulation. We present this approach and the corresponding branch-and-cut strategy in order to solve the problem in different variants, together with experimental results that show its practical applicability on real world instances.

2 - Compact MIP Models for the Resource-Constrained Project Scheduling Problem

Alexander Tesch, Zuse Institute Berlin (ZIB), Takustrafle 7, Berlin, 14195, Germany, tesch@zib.de

In the resource-constrained project scheduling problem (RCPSP) a set of jobs is scheduled non-preemptively subject to multidimensional resource constraints and precedence restrictions, whereby the makespan is minimized. Many integer programming models use time-discretization where the number of variables depends on the required time horizon. We consider compact models where the size is polynomial in the number of jobs. For this, we present new models with stronger relaxations compared to recent approaches from the literature. The models are further extended by strong linear lower bounds and cutting plane generation during MIP solving. Computational studies show that our model is very effective on smaller instances of the PSPLIB.

3 - Exact Solutions for the 2D-Bin and Strip Packing Problems using Integer Linear Programming

Nestor Cid-Garcia, Universidad Autónoma de Nuevo León, Av. Universidad SN, Ciudad Universitaria, San Nicolas de los Garza, NL, 66450, Mexico, nxtr.cd@gmail.com, Yasmìn Rios-Solis

We present a novel two-stage approach to obtain exact solutions for the two-dimensional bin and strip packing problems. In the literature, the best resolution methodologies are based on metaheuristics methods, which do not guarantee the solution optimality. Experimental results on literature benchmarks show that with our approach, we can verify that many of the best solutions given by theses metaheuristics are indeed the optimal ones.

■ ThC24

24- Benedum

Tight Relaxations

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Stefan Vigerske, P.O. Box 40 59, Frechen, Germany, stefan@gams.com

1 - Deriving Improved Convex Relaxations from a Representation Result for Mixed-integer Convex Sets

Dennis Michaels, Technische Universitaet Dortmund, Fakultaet fuer Mathematik, Vogelpothsweg 87, Mathematik, TU Dortmund, Dortmund, 44227, Germany, dennis.michaels@math.tu-dortmund.de, Martin Ballerstein, Nick Mertens, Robert Weismantel

In this talk, we present a representation result for mixed-integer convex sets that allows us to describe the convex hull of a vector-valued function by the convex hulls of single real-valued functions. The result can be useful to define improved convex relaxations for mixed-integer nonlinear optimization problems. Some examples are reported showing the usefulness of the presented approach.

2 - Recent Advances in Solving MINLPs with SCIP

Benjamin Mueller, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, benjamin.mueller@zib.de

The constraint integer program framework SCIP solves convex and nonconvex mixed-integer nonlinear programs (MINLPs) to global optimality via spatial branch-and-bound over a linear relaxation. In this talk, we present recent advances and new extensions of SCIP to generate linear underestimators for convex envelopes and for optimality-based domain propagation. We evaluate the performance impact of those new algorithmic ideas on the MINLPLib2 and other public instance libraries.

3 - On Outer-Approximations of Convex Regions

Felipe Serrano, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, serrano@zib.de, Robert Schwarz, Ambros Gleixner

Outer-approximation of the feasible region is a fundamental technique for solving general MINLPs. As expected, this technique is sensitive to the tightness of the outer-approximation. In the convex case, it is standard to generate outer-approximation cuts based on gradient information of the constraints. We show that a naive implementation does not always give a tight approximation and how we can improve it with the help of some basic tools from convex analysis.

■ ThC25

25- Board Room

Control and Optimization for Power Grids

Cluster: Optimization in Energy Systems

Invited Session

Chair: Pascal Van Hentenryck, NICTA, Australia, pascal.vanhentenryck@nicta.com.au

1 - Vulnerability Analysis of Power Systems

Taedong Kim, University of Wisconsin - Madison, CS Dept., 1210 W. Dayton Street, Madison, WI, 53706, United States of America, tdkim@cs.wisc.edu, Stephen Wright, Daniel Bienstock, Sean Harnett

Potential vulnerabilities in a power grid can be exposed by identifying transmission lines whose degradation causes maximum disruption to the grid. In this study, we model the grid by AC power flow equations, and assume that attacks take the form of increased impedance along transmission lines. We quantify disruption in two ways: (a) overall deviation of the voltages at the buses from 1.0 per unit (p.u.), and (b) the minimal amount of load that must be shed in order to restore the grid to stable operation. We describe optimization formulations of the problem of finding the most disruptive attack and customized algorithms for solving these problems. Experimental results on 118-bus system and 2383-bus system are presented.

2 - Natural Gas System Operations and Expansion Planning with Convex Relaxations

Russell Bent, Los Alamos National Laboratory, DSA-4: Energy & Infrastructure Analysis, Los Alamos, NM, 87545, United States of America, rbent@lanl.gov

The natural gas industry is a capital-intensive sustainable business where the construction and expansion of its infrastructure involves a considerably large amount of capital expenditures. The standard approach for an expansion planning problem typically entails challenging non-linear non-convex feasible operating domains. In this study, we present a mathematical formulation for the expansion and reinforcement of a natural gas transmission network that operates under steady-state conditions. The underlying model captures gas operational constraints, unknown-flow directions and on/off constraints typically required in design and expansion problems. The proposed model, in its original form, takes the form of a mixed-integer non-linear (MINLP) program whose non-convexity and integrality pose a great challenge to scalability and global convergence. Hence, we develop two relaxations as promising alternatives to handle large-scale instances. The first relaxation is based on piecewise linearization (PWL) technique and takes the form of a mixed-integer linear (MILP) program. The second relaxation is based on a second-order cones, which leads to a mixed-integer quadratic program (MIQP). A comprehensive set of computational experiments are conducted to validate and assess the computability of the models on a test bed of complex and large-scale cases that includes existing Belgian and German gas networks. The clear advantages of our approaches reside in their capability of handling cyclic and non-cyclic large network topologies and their robustness and scalability. Joint work with Conrado Borraz-Sanchez, Hassan Hijazi, Pascal van Hentenryck, and Scott Backhaus.

3 - Distributed Optimization Decomposition for Joint Economic Dispatch and Frequency Regulation

Enrique Mallada, Cal Tech, United States of America, mallada@caltech.edu

Economic dispatch and frequency regulation are typically viewed as fundamentally different problems in power systems, and hence are typically studied separately. In this work, we frame and study a joint problem that optimizes both slow timescale economic dispatch resources and fast timescale frequency regulation resources.We provide sufficient conditions under which the joint problem can be decomposed without loss of optimality into slow and fast timescale problems. These slow and fast timescale problems have appealing interpretations as the economic dispatch and frequency regulation problems respectively. Moreover, the fast timescale problem can be solved using a distributed algorithm that preserves the stability of the network during transients. We also apply this optimal decomposition to propose an efficient market mechanism for economic dispatch that coordinates with frequency regulation.

■ ThC26

26- Forbes Room

Stochastic Optimization in Logistics and Service

Cluster: Stochastic Optimization

Invited Session

Chair: Alexei Gaivoronski, Professor, NTNU, Alfred Geitz vei 3, Trondheim, Norway, Alexei.Gaivoronski@iot.ntnu.no

1 - Lattice-based Methods for Deterministic and Stochastic Resource Constraint Shortest Path Problems

Axel Parmentier, PhD Student, CERMICS - ENPC, 6 et 8 avenue Blaise Pascal, Cite Descartes, Champs sur Marne, 77420, France, axel.parmentier@cermics.enpc.fr

We introduce a lattice ordered monoid framework for the Resource Constrained Shortest Path problem. This lattice ordered framework has two strengths: first, it can handle stochastic resources, probabilistic constraints, and risk measures as cost functions. Second, lattice ordered monoid structure enables to compute tight bounds in polynomial time, and to use these bounds to discard partial paths in an exact label algorithm. The efficiency of the whole approach is proved through extensive numerical experiments.

2 - Stochastic Bilevel Problems with Application to Telecommunications Networks

Alexei Gaivoronski, Professor, NTNU, Alfred Geitz vei 3, Trondheim, Norway, Alexei.Gaivoronski@iot.ntnu.no, Abdel Lisser

We consider several problems that arise in analysis of relationships between different actors providing services in Internet ecosystem. It is shown that these problems can be formalized as bilevel stochastic optimization problems. We study their properties and show how they can be solved with stochastic gradient methods. Interestingly, the stochastic problems of this type possess more regular properties and can be solved more easily than their deterministic counterparts.

■ ThC27

27- Duquesne Room

Message Passing Algorithms and Statistical Inference

Cluster: Combinatorial Optimization

Invited Session

Chair: Amin Coja-Oghlan, Goethe University, 10 Robert Mayer St, Frankfurt, 60325, Germany, acoghlan@math.uni-frankfurt.de

1 - Concavity of Reweighted Kikuchi Approximation

Po-Ling Loh, The Wharton School of the University of Pennsylvania, loh@wharton.upenn.edu

We analyze a reweighted version of the Kikuchi approximation for estimating the log partition function of a product distribution defined over a region graph. We establish sufficient conditions for the concavity of our reweighted objective function in terms of weight assignments in the Kikuchi expansion, and show that a reweighted version of the sum product algorithm applied to the Kikuchi region graph will produce global optima of the Kikuchi approximation whenever the algorithm converges. When the region graph has two layers, corresponding to a Bethe approximation, we show that our sufficient conditions for concavity are also necessary.

2 - Message-Passing Algorithms in Statistical Learning

Mohsen Bayati, Stanford University, 655 Knight Way, Stanford, CA, United States of America, bayati@stanford.edu

In this talk I will survey some recent results on applications of message-passing algorithm in high-dimensional statistics. In particular, I will describe the state evolution formalism that provides a rigorous framework to study statistical properties of solutions to optimization problems arising in high dimensional data analysis.

3 - Loopy Annealing Belief Propagation for Vertex Covers and Matchings

Marc Lelarge, INRIA-ENS, 23 avenue d'Italie, Paris, 75013, France, marc.lelarge@ens.fr

For the minimum cardinality vertex cover and maximum cardinality matching problems, the max-product form of belief propagation (BP) is known to perform poorly on general graphs. In this paper, we present an iterative loopy annealing BP (LABP) algorithm which is shown to converge and to solve a Linear Programming relaxation of the vertex cover or matching problem on general graphs. LABP finds a minimum half-integral vertex cover (hence provides a 2-approximation) and a maximum fractional matching on any graph. We also show that LABP finds a minimum size vertex cover for any bipartite graph.

■ ThC28

28- Liberty Room

Advances in Theory and Computation of Facility Location and Network Design Problems

Cluster: Telecommunications and Networks

Invited Session

Chair: Manish Bansal, Northwestern University, 2145 Sheridan Road, Department of Industrial Engineering and, Evanston, IL, 60208, United States of America, bansal@tamu.edu

1 - Chance-Constrained Multi-Terminal Network Design Problem

Minjiao Zhang, The University of Alabama, 361 Stadium Dr., Tuscaloosa, AL, 35406, United States of America, mzhang@cba.ua.edu, Yongjia Song

We study a chance-constrained multi-terminal network design problem, which is a stochastic variant of Steiner tree problems. We study formulations using valid inequalities that require different separation efforts. We conduct a computational test to show their performance.

2 - Three-Partition Inequalities for Constant Capacity Capacitated Fixed-Charge Network Flow Problems

Andres Gomez, PhD Student, University of California at Berkeley, Etcheverry Hall, Berkeley, CA, United States of America, a.gomez@berkeley.edu, Simge Kucukyavuz, Alper Atamturk

We give new valid inequalities for the capacitated fixed-charge network flow problem based on a three-partitioning of the nodes. The three-partitioning inequalities are facets for the three-partition polytope and include the flow cover inequalities as a special case. We discuss the constant capacity case and describe a polynomial separation algorithm for the inequalities. Finally, we report our computational results with the new inequalities in networks with different characteristics.

■ ThC29

29- Commonwealth 1

Large-Scale Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Angelia Nedich, University of Illinois, 1308 West Main Street, Urbana, IL, 61801, United States of America, angelia@illinois.edu

1 - Decentralized Online Optimization with Global Objectives and Local Communication

Maxim Raginsky, University of Illinois at Urbana-Champaign, 1308 W Main St, UIUC Coordinated Science Lab, Urbana, IL, 61801, United States of America, maxim@illinois.edu, Soomin Lee, Angelia Nedich

We consider a decentralized online convex optimization problem in a static undirected network of agents, where each agent controls only one coordinate of the global decision vector. For such a problem, we propose a decentralized variant of Nesterov's primal-dual algorithm with dual averaging. To mitigate the disagreements on the primal-vector updates, the agents implement a generalization of the local information-exchange dynamics recently proposed by Li and Marden. We show that, when the stepsize is chosen appropriately and the objective functions are Lipschitz with Lipschitz gradients, the resulting regret is sublinear in the time horizon. We also prove an analogous bound on the expected regret for the stochastic variant of the algorithm.

2 - Convergence Rates in Decentralized Optimization

Alexander Olshevsky, University of Illinois, 1308 West Main Street, Urbana, IL, 61801, United States of America, aolshev2@illinois.edu

The widespread availability of copious amounts of data has created a pressing need to develop optimization algorithms which can work in parallel when input data is unavailable at a single place but rather spread throughout multiple locations. In this talk, we consider the problem of optimizing a sum of convex (not necessarily differentiable) functions in a network where each node knows only one of the functions; this is a common model which includes as particular cases a number of distributed regression and classification problems. Our main result is a distributed subgradient method which simultaneously achieves the optimal scalings both with time and the network size for this problem.

3 - Random Block-Coordinate Gradient Projection Algorithms

Angelia Nedich, University of Illinois, 1308 West Main Street, Urbana, IL, 61801, United States of America, angelia@illinois.edu, Chandramani Singh, Rayadurgam Srikant

We discuss gradient projection algorithms based on random partial updates of decision variables. These algorithms generalize random coordinate descent methods. We analyze these algorithms with and without assuming strong convexity of the objective functions. We also present an accelerated version of the algorithm based on Nesterov's two-step gradient method. In each case, we prove convergence and provide a bound on the rate of convergence. We see that the randomized algorithms exhibit similar rates of convergence as their full gradient based deterministic counterparts.

■ ThC30

30- Commonwealth 2

Approximation and Online AlgorithmsI

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Tri-Dung Nguyen, University of Southampton, Mathematical Sciences, Southampton, SO17 3TJ, United Kingdom, T.D.Nguyen@soton.ac.uk

1 - The Online Resource Constrained Project Scheduling Problem with Bounded Multitasking

Carlos Cardonha, Research Staff Member, IBM Research, Rua Tutoia, 1157, São Paulo, Brazil, carlos.cardonha@gmail.com, Victor Cavalcante, Ricardo Herrmann

The Resource Constrained Project Scheduling Problem with Bounded Multitasking (RCPSPBM) is about the assignment of tickets to analysts with varying performance levels and bounded multitasking capacity. An optimal plan minimizes penalties originated from cognitive overheads, which occur whenever analysts work on two or more requests simultaneously, and from due date violations. In this work, we investigate theoretical and practical aspects of O-RCPSPBM, the online version of the problem. Computational experiments based on real-world scenarios show that the algorithm proposed in this work outperforms a greedy method that is typically used in the industry.

2 - Optimizing Prices in Descending Clock Auctions

Tri-Dung Nguyen, University of Southampton, Mathematical Sciences, Southampton, SO17 3TJ, United Kingdom, T.D.Nguyen@soton.ac.uk, Tuomas Sandholm

A descending clock auction (DCA) is a mechanism for buying items from multiple potential sellers where bidder-specific prices are decremented over the course of the auction. DCAs have been proposed as the method for procuring spectrum from existing holders in the FCC imminent incentive auctions so spectrum can be repurposed to higher-value uses. We develop an optimization model and computational methods for setting prices to offer the bidders in each round. We prove attractive properties of this and present experiments on the case of FCC incentive auctions. Extension to the multi-option case is also presented where Markov chains are used to represent the random states of the auctions.

Thursday, 2:45pm - 4:15pm

■ ThD01

01- Grand 1

Complementarity/Variational Inequality V

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Jie Sun, Curtin University, Department of Mathematics and Statistics, Australia, Jie.Sun@curtin.edu.au

1 - Distributed Alternating Direction Method of Multipliers (ADMM): Performance and Network Effects

Ermin Wei, Northwestern University, 2145 Sheridan Rd, Tech L310, Evanston, IL, 60208, United States of America, ermin.wei@northwestern.edu, Asu Özdaglar, Shimrit Shtern

We consider the distributed multi-agent optimization problem: a network of agents is solving a global optimization problem where the objective function is given by the sum of privately known convex, not necessarily smooth, local objective functions and the decision variable is shared among all agents. For this problem, we present a fully distributed Alternating Direction Method of Multipliers (ADMM) based method. We show that this method achieves the best rate of convergence for this general class of distributed convex problems. In particular, the rate guarantee is much faster than the popular (sub)gradient based methods. We further investigate the dependency of algorithm performance bounds on the underlying network structure.

2 - A Bi-Level Model and Solution Techniques for a Demand Response Policy

Yanchao Liu, Senior Analyst, Sears Holdings Corporation, E3-364B, 3333 Beverly Road, Hoffman Estates, IL, 60179, United States of America, yliu@discovery.wisc.edu, Michael Ferris

A bi-level optimization model is proposed for a demand response policy in the energy markets. In this model, the lower level performs the economic dispatch of energy and generates the price and the upper level minimizes the total amount of demand response subject to a net benefit requirement. In the reformulation, the nonconvex complementarity conditions of doubly bounded variables are transformed to SOS2 constraints. For realistic instances, we exploit the fast local solution from a nonlinear programming solver as well as LP-based bound strengthening within a mixed integer/SOS2 formulation. The model is tested against various data cases and settings, and generates useful insight for demand response dispatch operations in practice.

3 - Stochastic Vatiational Inequality – A Risk Measure Point of View

Jie Sun, Curtin University, Department of Mathematics and Statistics, Australia, Jie.Sun@curtin.edu.au

We study a stochastic variational inequality model and its application to multistage stochastic optimization problems. We in particular discuss the impact to theory and computation of introducing risk measures to the stochastic optimization problems.

■ ThD02

02- Grand 2

Optimization of Natural Gas Networks

Cluster: Optimization in Energy Systems

Invited Session

Chair: Alexander Martin, FAU Erlangen-Nürnberg, Department Mathematik, Cauerstr 11, Erlangen, Germany, alexander.martin@math.uni-erlangen.de

1 - Optimum Gas Flows: Exact Results and Efficient Heuristics

Sidhant Misra, Los Alamos National Laboratory, Los Alamos, NM, 87545, United States of America, sidhant172@gmail.com, Marc Vuffray, Michael Chertkov

Natural gas networks transport gas from sources to loads using high pressure pipes. Compressors are installed to compensate for the pressure drop due to the flows. We first consider the problem of minimizing the cost of compression subject to bounds on pressure. For tree networks we show that this transforms into a Geometric Program (GP). For meshed networks we devise a heuristic based on GP and test its performance on real networks. Second, we consider the problem of maximizing the gas transported to loads under pressure bounds. We obtain a mixed integer convex relaxation as well as a heuristic that uses the variational form of the gas flow equations, and validate performance of the algorithms on real gas networks models.

2 - Monotonicity of Dissipative Flow Networks Renders Robust Maximum Throughput Tractable

Marc Vuffray, Postdoctoral Research Associate, Los Alamos National Laboratory, CNLS, MS B258, Los Alamos, NM, 87545, United States of America, vuffray@hotmail.com, Michael Chertkov, Sidhant Misra

We consider flow networks in which flows are related to the drop of a nodal potential. The network contains three sorts of nodes: sources that inject flows, terminals that extract flows and sinks that withdraw an uncertain amount of flows. The objective is to maximize the throughput from sources to terminals such that potentials stay within prescribed bounds. We show that the robust version of this problem with respect to the uncertainty at the sinks is tractable. We first prove that the potential are monotonic functions of the withdrawals. This implies that the infinitely many constraints arising from the robustification can be replaced by only two constraints. We illustrate this general result with the natural gas transmission network.

3 - Computational Challenges in Modeling, Optimization and Control of Natural Gas Networks

Michael Chertkov, Los Alamos National Laboratory, Los Alamos, NM, United States of America, chertkov@lanl.gov, Russell Bent, Scott Backhaus

Challenges in simulation, optimization and control of natural gas transmission systems are reviewed in this presentation of the Grid Science Team @ LANL. We pose and analyze multi-level deterministic and stochastic, robust or distributionally-robust optimization problems. In their most general formulation the constraints includes PDEs that model the physics of gas flows as well as safety, operational and risk margins. We make the problems tractable through novel approximations and relaxations. These include adiabatic approximations and perturbative approximations that replace the PDEs with ODEs. A brief description of our path forward and future plans concludes the presentation.

■ ThD03

03- Grand 3

Algorithms for Network Interdiction

Cluster: Combinatorial Optimization

Invited Session

Chair: S. Thomas McCormick, Professor, Sauder School of Business, UBC, 2053 Main Mall, Vancouver, BC, V7C1Z2, Canada, thomas.mccormick@sauder.ubc.ca

1 - Routing Through A Network with Online Failures

Gianpaolo Oriolo, Professor, University of Rome Tor Vergata, Via del Politecnico, 1, Rome, Italy, oriolo@disp.uniroma2.it

We consider some routing problems where one player aims at routing some commodity from a source S to a sink T through a network G and an adversary removes arc in G. We deal with the setup in which the adversary reveals the identity of the deleted arcs just before the routing player attempts to use them, thus forcing her to rerouting. We consider several problem, such as that of choosing a nominal path as to minimize the worst case arrival time at T, or that of choosing a nominal flow as to maximize the worst case amount of flow sent to T. We solve some models, discuss some game-theoretic extension and leave a few open problems. The talk is based on joint works with David Adjiashvili, Tom McCormick, Jannik Matuschke and Marco Senatore.

2 - Fare Evasion in Transit Networks

Jannik Matuschke, University of Rome Tor Vergata, Via del Politecnico 1, Rome, 00133, Italy, jannik.matuschke@gmail.com, Jose Correa, Vincent Kreuzen, Tobias Harks

We study bilevel programming models for optimizing fare inspection in public transit networks. First, the network operator determines probabilities for inspections at different locations, to which the (fare-evading) passengers respond by optimizing their routes. We study both a non-adaptive variant, in which passengers follow an a priori selected route, and an adaptive variant, in which update their route on the way. For the passengers' subproblem, we design exact and approximate algorithms and prove a tight bound of 3/4 on the ratio of the optimal adaptive and non-adaptive strategy. For the operator's problem, we design an LP-based approximation and a local search procedure and evaluate them in an extensive computational study.

3 - Parametric Network Flows

S. Thomas McCormick, Professor, Sauder School of Business, UBC, 2053 Main Mall, Vancouver, BC, V7C1Z2, Canada, thomas.mccormick@sauder.ubc.ca

We review the parametric optimization framework of Topkis, and how the parametric min cut results of GGT fit into the framework. This framework gives two main results: a Structural Property that min cuts are monotone in the parameter, and an Algorithmic Property, that one can compute all min cuts in the same time as solving the non-parametric problem. We extend these results to parametric capacity and parametric rewards versions of "Max Reward Flow", a "max" version of Min Cost Flow. We prove that the Structural Property again holds, and we adapt the Relax algorithm of Bertsekas to also get the Algorithmic Property. We further indicate how to extend the results to parametric Weighted Abstract Min Cut, and to other problems.

■ ThD04

04- Grand 4

Nonnegative Matrix Factorization and Related Topics II

Cluster: Conic Programming

Invited Session

Chair: Stephen A. Vavasis, University of Waterloo, 200 University Avenue W., Waterloo, ON, N2L 3G1, Canada, vavasis@uwaterloo.ca

Co-Chair: Nicolas Gillis, University of Mons, Rue de Houdain 9, Mons, Ha, 7000, Belgium, nicolas.gillis@umons.ac.be

1 - Learning Overcomplete Latent Variable Models through Tensor Methods

Majid Janzamin, University of California - Irvine, CA, mjanzami@uci.edu, Anima Anandkumar, Rong Ge

We provide guarantees for learning latent variable models emphasizing on the overcomplete regime, where the latent dimensionality exceeds the observed dimensionality. In particular, we consider multiview mixtures, ICA, and sparse coding models. Our main tool is a tensor decomposition algorithm that works in the overcomplete regime. We initialize the method with labels in the semi-supervised setting, and we perform a simple SVD-based initialization in the unsupervised setting. For third order tensors, in the former setting, we establish learning guarantees when the number of components scales as $k=o(d^{1.5})$, where d is the observed dimension. In the latter setting, the guarantees are provided under the stricter condition $k \le O(d)$.

2 - Archetype Pursuit for Archetypal Analysis and Non-negative Matrix Factorization

Yuekai Sun, Stanford University, yuekai@stanford.edu, Anil Damle

Archetypal analysis and non-negative matrix factorization and are staples in a statisticians toolbox for dimension reduction and exploratory data analysis. We describe a unified approach to both NMF and archetypal analysis by reducing both problems to finding extreme points of the data cloud. We develop an approach that requires O(pklog(k)) floating-point operations to find all k extreme points with high probability. We refer to our approach as archetype pursuit. For modern massive datasets that are too large to fit on a single machine and must be stored in a distributed setting, archetype pursuit makes only a small number of passes over the data. In fact, it is possible to perform NMF or archetypal analysis with two passes over the data.

3 - Exact and Heuristic Algorithms for Semi-Nonnegative Matrix Factorization

Nicolas Gillis, University of Mons, Rue de Houdain 9, Mons, Ha, 7000, Belgium, nicolas.gillis@umons.ac.be, Abhishek Kumar

Given a matrix M (not necessarily nonnegative) and a factorization rank r, semi-nonnegative matrix factorization (semi-NMF) looks for a matrix U with r columns and a nonnegative matrix V with r rows such that UV is the best possible approximation of M according to some metric. In this talk, we study the properties of semi-NMF from which we develop exact and heuristic algorithms. In particular, we propose an exact algorithm (that is, an algorithm that finds an optimal solution) for a certain class of matrices which we use as a heuristic for matrices not belonging to that class. Numerical experiments illustrate that this second heuristic performs extremely well, and allows us to compute optimal semi-NMF decompositions in many situations.

■ ThD05

05- Kings Garden 1

Iterative Methods for Inverse Problems

Cluster: Nonlinear Programming

Invited Session

Chair: Serge Gratton, Prof. Dr., CERFACS, 42 avenue Gaspard Coriolis, Toulouse, France, serge.gratton@enseeiht.fr

1 - A Low-Memory Approach for Best-State Estimation of Hidden Markov Models with Model Error

Mihai Anitescu, Dr., Argonne, anitescu@mcs.anl.gov, Xiaoyan Zeng, Wanting Xu, Emil Constantinescu

We present a low-memory approach for the best-state estimate (data assimilation) of hidden Markov models where model error is considered. In particular, our findings apply to the 4DVar framework. The storage needed by our estimation framework, while including model error, is dramatically reduced from O(number of time steps) to O(1) or O(J) if J checkpointing or multiple shooting segments are used. The reduction device is the restriction of the other states by recursively enforcing the optimality conditions. Our findings are demonstrated by numerical experiments on Burgers' equations.

2 - Optimizing Neural Networks with Kronecker-factored Approximate Curvature

James Martens, PhD Candidate, University of Toronto, 10 King's College Road, Toronto, Canada, jmartens@cs.toronto.edu, Roger Grosse

We propose an efficient method for approximating natural gradient descent in neural networks which we call Kronecker-factored Approximate Curvature (K-FAC). K-FAC is based on an efficiently invertible approximation of a neural network's Fisher information matrix which is neither diagonal nor low-rank, and in some cases is completely non-sparse. It is derived by approximating various large blocks of the Fisher as factoring as Kronecker products between two much smaller matrices. While only several times more expensive to compute than the plain stochastic gradient, the updates produced by K-FAC make much more progress optimizing the objective, which results in an algorithm that can be much faster in practice than SGD with momentum.

3 - Preconditioning Saddle Point Formulation of the Variational Data Assimilation

Selime Gurol, Dr., CERFACS, gurol@cerfacs.fr, Mike Fisher, Serge Gratton

In this talk we will address the numerical solution of the saddle point system arising from four dimensional variational (4D-Var) data assimilation with an emphasis on a study of preconditioning with low-rank updates. These updates can be found by solving two-sided secant equations. The saddle point formulation of 4D-Var allows parallelization in the time dimension. Therefore, it represents a crucial step towards improved parallel scalability of 4D-Var. We will present numerical results obtained from the Object Oriented Prediction System (OOPS) developed by European Centre for Medium-Range Weather Forecasts (ECMWF).

■ ThD06

06- Kings Garden 2

Computational Linear Programming II

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Ambros Gleixner, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, gleixner@zib.de

1 - A Specialized Interior-Point Method for Large-Scale Capacitated Multiperiod Facility Location

Jordi Castro, Prof., Universitat Politecnica de Catalunya, Dept. of Stats. and Operations Research, Barcelona, Spain, jordi.castro@upc.edu, Stefano Nasini, Francisco Saldanha

The capacitated facility location problem is a well known MILP, which has been efficiently solved by cutting plane procedures. We extend this solution procedure for a multiperiod variant of this problem. The resulting linear subproblems, one for time period, exhibit a block-angular structure which can be efficiently solved by a specialized interior-point method. This allows the formulation of world-wide facility location problems, of up to 3 time periods, 200 locations and 1 million customers, resulting in MILPs of 200 binaries and linear subproblems of up to 200 million variables. Those MILP instances are optimally solved in less than one hour of CPU time, while state-of-the-art solvers exhausted the 144 Gigabytes of available memory.

2 - Addressing Degeneracy in the Dual Simplex Algorithm using a Decompositon Approach

Stephen Maher, Zuse Institute Berlin, Takustr. 7, Berlin, Germany, maher@zib.de, Ambros Gleixner, Matthias Miltenberger

The dual simplex algorithm is widely used in mathematical programming and is known as one of the most efficient methods for solving linear programs. However, the presence of dual degeneracy negatively impacts the algorithm efficiency. While many attempts have been made to reduce the impact of dual degeneracy, non-improving pivots still occur. We investigate a decomposition approach to reduce the rows of a linear program to decrease the number of degenerate pivots. The proposed approach forms two problems, which are solved iteratively, aimed at identifying pivots that will provide an objective function improvement. Applying this decomposition aims achieve optimality with a reduced the number of iterations in the dual simplex algorithm.

3 - Glop: An Open-source Linear Programming Solver

Bruno De Backer, Google, 8 rue de Londres, Paris, 75009, France, bdb@google.com, Emmanuel Guéré, Frédéric Didier

We introduce Glop, a new open-source linear programming solver developed at Google. We explain the factors that led to developing (yet) another implementation and the design choices that we made. We present performance results in terms of speed, precision and code size. We conclude with possible future directions for Glop.

■ ThD07

07- Kings Garden 3

Advances in Integer Programming VIII

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - Non Total-Unimodularity Neutralized Simplicial Complexes

Bala Krishnamoorthy, Washington State University, 14204 NE Salmon Creek Ave, Vancouver, WA, 98686, United States of America, bkrishna@math.wsu.edu, Gavin Smith

We study a class of integer linear programs arising from algebraic topology that have interesting connections to total unimodularity (TU). We define a condition where the constraint matrix is not TU, but integral optimal solutions are guaranteed to exist. Thus the polytope of the LP may not be integral, but an integral optimal vertex exists for every integral right-hand side and every relevant objective function. A preprint is available at http://arxiv.org/abs/1304.4985.

2 - Diverse Vectors Selection: A Novel Approach to Model the Uniform Discrepancy

Giorgio Sartor, SUTD, 8 Somapah Road, Singapore, 487372, Singapore, giorgio_sartor@mymail.sutd.edu.sg, Giacomo Nannicini

In some situations a single solution to a mathematical program might not be sufficient, e.g. the problem cannot be modeled exactly. In these cases, it is better to provide a set of diverse solutions to the decision maker. We study the possibility of using the Uniform Discrepancy as a diversity measure and we propose an MILP model in order to select a set of diverse solutions from a given pool of feasible solutions. We provide preliminary computational evaluation of different diversity measures on a test set, commenting on the results.

3 - Branching as a Ranking and Selection Problem with Multiple Objectives

Jawad El-Omari, Lead Researcher, ORTEC, Houtsingel 5, Zoetermeer, 2719 EA, Netherlands, jawad.elomari@gmail.com

We propose a new branching policy for mixed integer linear programs that relies mainly on statistical methods to understand, and to some extent guide, the growth of a search tree. The policy accounts for: multiple performance measures simultaneously; the mean, variance, and covariance of the branching variables' performance history; and finally, changes in the performance distribution over time. Empirical evaluation against the default branching policy in CPLEX, strong branching, and pseudo-cost branching, showed significant reduction in running time and tree size.

ThD08

08- Kings Garden 4

Convex Optimization and Statistical Learning

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Venkat Chandrasekaran, Cal Tech, 1200 E. California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, venkatc@caltech.edu

1 - Nearly Linear Time Algorithms for Structured Sparsity

Chinmay Hegde, MIT, 32 Vassar St, G564, Cambridge, MA, 02139, United States of America, chinmay@csail.mit.edu

Structured sparsity has been proven beneficial in a number of applications in statistical learning and signal processing. However, these benefits do not come for free: enforcing complex structures in data typically involves cumbersome, computationally intensive algorithms. I will outline a series of new methods for structured sparse modeling that integrate ideas from combinatorial optimization and approximation algorithms. For several structure classes, these methods enjoy a nearly linear time complexity, thereby enabling their application to massive datasets.

2 - The Entropic Barrier: A Simple and Optimal Universal Self-Concordant Barrier

Sebastien Bubeck, Microsoft, Microsoft campus, Redmond, United States of America, sebubeck@microsoft.com, Ronen Eldan

A fundamental result in the theory of Interior Point Methods is Nesterov and Nemirovski's construction of a universal self-concordant barrier. In this talk I will introduce the entropic barrier, a new (and in some sense optimal) universal self-concordant barrier. The entropic barrier connects many topics of interest in Machine Learning: exponential families, convex duality, log-concave distributions, Mirror Descent, and exponential weights.

3 - Convex Regularization with the Diversity Function

Maryam Fazel, Associate Professor, University of Washington, Campus Box 352500, Seattle, WA, 98195, United States of America, mfazel@uw.edu, Amin Jalali, Lin Xiao

We propose a new class of penalties, called diversity functions, that can promote orthogonality among a set of vectors in a vector space, with applications in hierarchical classification, multitask learning, and estimation of vectors with disjoint supports. We give conditions under which the penalties are convex, show how to characterize the subdifferential and compute the proximal operator, and discuss efficient optimization algorithms. Numerical experiments on a hierarchical classification application are presented.

ThD09

09- Kings Garden 5

Robust Optimization and Combinatorial Optimization

Cluster: Robust Optimization

Invited Session

Chair: Jannis Kurtz, Technische Universitaet Dortmund, Vogelpothsweg 87, Dortmund, 44227, Germany, jannis.kurtz@math.tu-dortmund.de

1 - Uncorrelated Ellipsoidal Uncertainty in Combinatorial Optimization and Markov Decision Processes

Anna Ilyina, TU Dortmund, Vogelpothsweg 87, Dortmund, Germany, anna.ilyina@tu-dortmund.de, Frank Baumann, Christoph Buchheim

In robust binary optimization an uncertain objective function must often be optimized over some combinatorial structure. We present an exact algorithm based on Lagrangean decomposition allowing to separate these two aspects. Particularly in the uncorrelated ellipsoidal uncertainty case our approach is well-suited since the unrestricted case can be solved efficiently. Our approach is also applicable in the area of Markov decision processes with rewards-uncertainty where it is the only algorithm devised so far.

2 - Min-Max-Min Robustness: Combinatorial Optimization under Uncertainty Based on Multiple Solutions

Jannis Kurtz, Technische Universitaet Dortmund, Vogelpothsweg 87, Dortmund, 44227, Germany, jannis.kurtz@math.tu-dortmund.de, Christoph Buchheim

In the classical min-max approach to robust combinatorial optimization, a feasible solution is computed that optimizes the worst case over a given set of scenarios. As is well known, this approach is very conservative. We present a different approach: the objective is to compute k feasible solutions such that the best of these solutions for each given scenario is worst-case optimal, i.e., we model the problem as a min-max-min problem. Using a polynomial-time oracle algorithm, we show that the problem of choosing k min-max-min optimal solutions is as easy as the underlying combinatorial problem if k is greater or equal to the dimension plus one and if the uncertainty set is convex.

3 - On Robust Solutions to Uncertain Linear Complementarity Problems and their Variants

Yue Xie, Dr Uday Shanbhag, 445 Waupelani Dr, State College, PA, 16801, United States of America, yux111@psu.edu, Uday Shanbhag

Variational inequality and complementarity problems have found utility in modeling a range of optimization and equilibrium problems. Yet, little progress has been seen in the context of obtaining robust solutions for uncertain variational inequality problems in a tractable fashion. In a distribution-free regime, we present an avenue for obtaining robust solutions to uncertain monotone and a subclass of non-monotone linear complementarity problems via a low-dimensional convex program. More generally, robust solutions to uncertain non-monotone LCPs can be provided by customizing an existing global optimization scheme.

ThD10

10- Kings Terrace

Portfolio Allocation and Risk Measures in Optimization

Cluster: Finance and Economics

Invited Session

Chair: Luis Zuluaga, Assistant Professor, 200 West Packer Avenue, Bethlehem, PA, 18015, United States of America, luz212@lehigh.edu

1 - Alternating Direction Methods for Nonconvex Optimization with Applications to Risk Parity/Budgeting

Xi Bai, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, 18015, United States of America, abcbaixi@gmail.com, Reha Tutuncu, Katya Scheinberg

The risk parity portfolio selection problem aims to find such portfolios for which the contributions of risk from all assets are equally weighted. In this talk, we propose a nonconvex least-squares model whose set of optimal solutions includes all risk parity solutions. We generalize the setting further by considering a class of nonlinear, nonconvex functions which admit a (non separable) two-block representation with special structure. We then develop alternating direction and alternating linearization schemes for such functions and analyze their convergence and complexity.

2 - Preference Robust Risk Measures and Optimization

Jonathan Li, Telfer School of Management, University of Ottawa, 55 Laurier Avenue East, Ottawa, Canada, Jonathan.Li@telfer.uottawa.ca, Erick Delage

Popular risk measures such as variance, VaR, or CVaR may not represent the decision maker's true risk attitude. We present a novel preference robust risk minimization framework that provides for the first time the means of identifying and optimizing a risk measure that account precisely for (neither more nor less than) what we know of the risk preferences of a decision maker. We show how this preference robust risk minimization problem can be solved numerically by formulating convex optimization problems of reasonable size. Numerical experiments on a portfolio selection problem, where the problem reduces to a linear program, will illustrate the advantage of accounting for the fact that the information about risk perception is limited.

3 - Multi-Period Portfolio Optimization with Alpha Decay

Kartik Sivaramakrishnan, Axioma, 400 Northridge Road, Suite 800, Atlanta, GA, 30350, United States of America, kksivara@axioma.com, Dieter Vandenbussche, Vishv Jeet

For long-term investors, multi-period optimization offers the opportunity to make "wait-and-see" policy decisions by including approximate forecasts and policy decisions beyond the rebalancing time horizon. We consider portfolio optimization with a composite alpha signal that is composed of a short-term and a long-term alpha signal. The short-term alpha better predicts returns at the end of the rebalancing period but it decays quickly. The long-term alpha has less predictive power but it decays slowly. We develop a "rolling-horizon" two stage multi-period algorithm that incorporates this alpha model and show that it generate portfolios that are likely to have a better realized performance than the traditional single-period MVO algorithm.

■ ThD11

11- Brigade

Trees and Adders in Chip Design

Cluster: Combinatorial Optimization

Invited Session

Chair: Jens Vygen, Professor, University of Bonn, Research Institute for Discrete Math., Lennestr. 2, Bonn, 53113, Germany, vygen@or.uni-bonn.de

1 - Two-Level Rectilinear Steiner Trees

Stephan Held, Bonn University, Lennestr. 2, Bonn, Germany, held@or.uni-bonn.de, Nicolas Kaemmerling

Given a set P of terminals in the plane and a partition of P into k subsets P_1,..., P_k, a two-level rectilinear Steiner tree consists of a rectilinear Steiner tree T_i connecting the terminals in each set P_i ($i=1,\dots,k$) and a top-level group Steiner tree connecting the trees T_1,..., T_k. The goal is to minimize the total length of all trees. This problem arises naturally in the design of low-power physical implementations of parity functions on a computer chip. We present a polynomial-time 1.63-factor approximation algorithm, as well as a 2.37-factor approximation algorithm with a practical running time of O(|P| log|P|). For fixed k, we develop a polynomial time approximation scheme (PTAS).

2 - Steiner Trees with Bounded RC-Delay

Rudolf Scheifele, Research Institute for Discrete Mathematics, University of Bonn, Lennestr. 2, Bonn, 53113, Germany, scheifele@or.uni-bonn.de

We consider the Minimum Elmore Delay Steiner Tree Problem, which arises as a key problem in VLSI design: Here, we are given a set of pins located on the chip which have to be connected by metal wires in order to make the propagation of electrical signals possible. Challenging timing constraints require that these signals travel as fast as possible. This is modeled as a problem of constructing a Steiner tree minimizing the Elmore delay between a source vertex and a set of sink vertices. The problem is strongly NP-hard even for very restricted special cases, and although it is central in VLSI design, no approximation algorithms were known until today. We give the first constant-factor approximation algorithm and show extensions in practice.

3 - Adder Optimization for Chip Design

Sophie Spirkl, Graduate Student, Princeton University, Fine Hall, Washington Road, Princeton, NJ, 08544, United States of America, sspirkl@princeton.edu, Stephan Held

We consider the problem of constructing adders with prescribed input arrival times. Most previous results implement parallel prefix graphs (e.g. Kogge-Stone) and are designed for uniform input arrival times. We generalize the concept of prefix graphs, which allows us to reduce single-output adder optimization problems to a tree structure, and we allow arbitrary input arrival times. For both single-output and full adders, we present efficient algorithms which construct adders that improve, even for uniform arrival times, upon previous results in the core objectives delay, size and fan-out.

■ ThD12

12- Black Diamond

Network Design

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Olivia Smith, IBM Research - Australia, 204 Lygon St, Carlton, Australia, livsmith@au1.ibm.com

1 - The Coopetition Hub-and-Dpoke Network Design

Cheng-chang Lin, Professor, National Cheng Kung University, 1 University Road, Tainan, 701, Taiwan - ROC, cclin@mail.ncku.edu.tw, Yu-Sing Lai

Carriers in network industries, design hub-and-spoke (H/S) networks and determine operations plans to maximize their respective profits. Shipments are routed and consolidated through a hub network, an economy of scale. The network also allows some of the outlying low-demand centers to be served, an economy of scope. Competitively, carrier may expand its H/S with additional pickup/delivery centers to increase its revenue, or new hubs to reduce operating cost. Cooperatively, carrier may utilize the competitor's carrying capacity with sharing of its revenue. This results a competitive and cooperative game. We modeled it as an integer program and used the less-than-truckload industry in Taiwan for numerical examples.

2 - Exact Algorithms for the Incremental Network Design with Shortest Paths

Olivia Smith, IBM Research - Australia, 204 Lygon St, Carlton, Australia, livsmith@au1.ibm.com, Chaitanya Rao

Incremental Network Design problems are a recently defined class of problems where a network problem must be solved repeatedly during construction of a subset of the network. The optimal order of construction minimises the total cost. Here we present a variety of exact algorithms for this problem with shortest path as the network problem. We demonstrate that non-LP branching algorithms can perform around 100 times faster than standard MIP on difficult instances.

■ ThD13

13- Rivers

Advances and Applications in Conic Optimization Part III

Cluster: Conic Programming

Invited Session

Chair: Masakazu Muramatsu, The University of Electro-Communications, 1-5-1 Chofugaoka, Chofu-shi, Tokyo, Japan, muramatu@cs.uec.ac.jp

Co-Chair: Mituhiro Fukuda, Tokyo Institute of Technology, 2-12-1-W8-41 Oh-okayama, Meguro-ku, Tokyo, 152-8552, Japan, mituhiro@is.titech.ac.jp

1 - Primal-Dual Interior-Point Methods for Hyperbolic Cone Programming and Beyond

Levent Tuncel, Professor, University of Waterloo, 200 University Avenue West, Dept. Combinatorics and Optimization, Waterloo, ON, N2L3G1, Canada, ltuncel@math.uwaterloo.ca, Tor Myklebust

We first discuss some fundamental ingredients of primal-dual interior-point methods for convex optimization. Then, our focus will turn to those convex optimization problems which can be formulated by utilizing convex cones which are hyperbolicity cones of some hyperbolic polynomials. Finally, we will present some interior-point algorithms and their theoretical features including their iteration complexity analysis.

2 - Primal-Dual Path Following Method for Solving Linear Semi-Infinite Semi-Definite Programs

Takayuki Okuno, Department of Management Science, Faculty of Engineering Division I, Tokyo University of Science, Shinjuku 162-8601, Tokyo, Japan, t_okuno@ms.kagu.tus.ac.jp, Masão Fukushima

The semi-infinite program (SIP) is represented with infinitely many inequality constraints, and has been studied extensively so far. Recently, for solving the SIPs with conic constrains such as second-order cone constraints and semi-definite matrix (SDM) constraints, local-reduction SQP-type or exchange-type algorithms has been developed. In this research, we consider the linear SIP involving finitely many SDM constraints (SISDP), and propose a primal-dual path following type algorithm for the SISDP, in which we solve only a certain quadratic program at each iteration unlike the existing methods solving a finitely relaxed SISDP sequentially. We study the global convergence property of the proposed algorithm.

3 - A Relative Interior Seeking Procedure for Second Order Cone Programming and Feasibility Issues

Bruno Lourenco, Tokyo Institute of Technology, 2-12-1-W8-41 Ookayama, Meguro-ku, Tokyo, Japan, flourenco.b.aa@m.titech.ac.jp, Masakazu Muramatsu, Takashi Tsuchiya

In this talk, we discuss a procedure to identify a relative interior point in the feasible region of a second order cone program (SOCP) by solving two optimization problems. This is less than the required for usual approaches based on Facial Reduction. We will also discuss a few subtle feasibility issues arising in SOCP such as weak infeasibility.

ThD14

14- Traders

Price of Anarchy I

Cluster: Game Theory

Invited Session

Chair: Paul Duetting, London School of Economics, Houghton Street, London, WC2A 2AE, United Kingdom, P.D.Duetting@lse.ac.uk

1 - Barriers to Near-Optimal Equilibria

Tim Roughgarden, Stanford University, 474 Gates, 353 Serra Mall, Stanford, CA, 94305, United States of America, tim@cs.stanford.edu

We explain when and how communication and computational lower bounds for algorithms for an optimization problem translate to lower bounds on the worst-case quality of equilibria in games derived from the problem. The most straightforward use of our lower bound framework is to harness an existing computational or communication lower bound to derive a lower bound on the worst-case price of anarchy (POA) in a class of games. This is a new approach to POA lower bounds, based on reductions in lieu of explicit constructions. Our lower bounds are particularly significant for designing games that have only near-optimal equilibria – ranging from the design of simple combinatorial auctions to the existence of effective tolls for routing networks.

2 - Composable and Efficient Mechanisms

Vasilis Syrgkanis, Microsoft Research, 641 Avenue of the Americas, New York, NY, United States of America, vasy@microsoft.com, Eva Tardos

We initiate the study of efficient mechanism design with guaranteed good properties when players participate in multiple different mechanisms simultaneously or sequentially. We define the class of smooth mechanisms and show that they result in high quality outcome in equilibrium both in the full information and in the Bayesian setting, as well as in learning outcomes. Our main result is to show that such mechanisms compose well: smoothness locally at each mechanism implies efficiency globally.

3 - Price of Anarchy for Auction Revenue

Darrell Hoy, PhD Candidate, Northwestern University, 104A Concord Ave, Somerville, MA, 02143, United States of America, darrell.hoy@gmail.com, Jason Hartline, Sam Taggart

This paper develops tools for welfare and revenue analyses of Bayes-Nash equilibria in asymmetric auctions with single-dimensional agents. We employ these tools to derive price of anarchy results for social welfare and revenue. Our approach separates the standard smoothness framework into two distinct parts, isolating the analysis common to any auction from the analysis specific to a given auction. This approach enables the first known revenue approximation results for the first-price and all-pay auctions in asymmetric settings.

ThD15

15- Chartiers

Rule-Based Optimization

Cluster: Global Optimization

Invited Session

Chair: Zelda Zabinsky, Professor, University of Washington, Industrial and Systems Engineering, Seattle, WA, 98195-2650, United States of America, zelda@u.washington.edu

1 - Tomograph Algorithms for Real-time Generation of Optimal Hybrid Control Models

Wolf Kohn, Professor and Chief Scientist, University of Washington, ISE Dept., Atigeo, LLC, Seattle, WA, 98195-2650, United States of America, wolfk@u.washington.edu, Zelda Zabinsky

Intelligent controllers for enterprise processes require amalgamation of behavioral rules of the dynamic operation to achieve desired performance. We propose a method that hybridizes a-priori knowledge with sensory information to create an active learning based model for the process. Our algorithm implements a data "Tomograph" that extracts a Hamiltonian representing the system. The Hamiltonian is continuously updated (active learning) and is used to derive control laws and strategies. The algorithm is illustrated on a microgrid.

2 - A Model-Based Approach To Multi-Objective Optimization

Joshua Hale, Georgia Institute of Technology, Atlanta, GA, United States of America, jhale32@gatech.edu, Enlu Zhou

We develop a model-based algorithm for the optimization of multiple objective functions that can only be assessed through black-box evaluation. The algorithm iteratively generates candidate solutions from a mixture distribution over the solution space, and updates the mixture distribution based on the sampled solutions' domination count such that the future search is biased towards the set of Pareto optimal solutions. We demonstrate the performance of the proposed algorithm on several benchmark problems.

3 - Near Optimal Hamiltonian Feedback Control via Chattering

Peeyush Kumar, PhD Student and Intern, University of Washington, Industrial and Systems Engineering, Atigeo, LLC, Seattle, WA, 98195-2650, United States of America, agaron@uw.edu, Wolf Kohn, Zelda Zabinsky

This paper presents a feedback control system implementing an approximation to optimal-measure based control using a chattering approximation. Hamiltonian functions represent the dynamics and criterion of a dynamical system implicitly, and may be estimated from sensory data or behavior rules. The chattering approximation on Hamiltonians leads to a control law realized by an optimization problem with linear constraints. This problem is solved iteratively with a moving window over a finite-horizon, using an open loop feedback strategy.

ThD16

16- Sterlings 1

Risk-Averse Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Darinka Dentcheva, Professor, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, ddentche@stevens.edu

1 - Methods for Risk-Averse Dynamic Programming in Clinical Trial Design

Curtis McGinity, Rutgers University, 100 Rockafeller Rd., Piscataway, NJ, 08854, United States of America, curtis.mcginity@rutgers.edu, Andrzej Ruszczynski, Darinka Dentcheva

We consider the problem of optimal risk-averse design of early stage clinical trials. We formulate the risk-averse Markov decision process, develop dynamic programming equations, and present solution methods over the infinite-dimensional state space. We compare the risk to that of several myopic and look-ahead policies.

2 - Radiation Therapy Design via Stochastic Orders

Constantine Vitt, Rutgers University, 1 Washington Park, Newark, NJ, 07102, United States of America, constantine.vitt@rutgers.edu, Darinka Dentcheva

Radiation therapy design optimizes the radiation dose delivery for the treatment of cancer. We propose a new design approach based on a probabilistic interpretation of the problem. We consider several stochastic orders for expressing the medical requirements regarding the dose distributions. The problem formulation facilitates the application of convex optimization tools and methods while keeping close control on the dose delivery. We propose specialized decomposition methods for solving the resulting optimization problems and report on the numerical results.

3 - Risk Preferences on the Space of Quantile Functions

Darinka Dentcheva, Professor, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, ddentche@stevens.edu, Andrzej Ruszczynski

A novel approach to quantification of law invariant risk preferences is proposed. We consider preference relations on the space of quantile functions defined by several axioms, which impose relations among comonotonic random variables. We infer the existence of a numerical representation of the preference relation in the form of a quantile-based measure of risk. Using conjugate duality theory, we develop a variational representation of the quantile-based measures of risk. Furthermore, we introduce a notion of risk aversion based on quantile functions, which enables us to derive an analogue of Kusuoka representation of coherent law-invariant measures of risk.

ThD17

17- Sterlings 2

Stochastic Optimization for Health Care Applications

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Siqian Shen, Assistant Professor, Department of Industrial and Operations Engineering, University of Michigan, 2793 IOE Building, 1205 Beal Avenue, Ann Arbor, MI, 48103, United States of America, siqian@umich.edu

1 - Vaccine Allocation in a Heterogeneous Population: A Stochastic Programming Approach

Christina Rulon, North Carolina State University, 400 Daniels Hall, Raleigh, NC, 27513, United States of America, cmrulon@ncsu.edu, Osman Ozaltin

Vaccination remains to be one of the most effective interventions for controlling many infectious diseases. In heterogeneous populations, it is important to know what fraction of each subgroup should be covered with a vaccine having certain characteristics to eliminate the infectious disease from the whole population. We propose a stochastic programming model based on a threshold surface characterization of critical vaccine allocation fractions. These fractions can provide epidemiologists with information about the best deployment of limited quantities of vaccine to contain the infectious disease.

2 - A Column Generation Approach for Stochastic Operating Room Scheduling

Zheng Zhang, University of Michigan, 1205 Beal Ave, Ann Arbor, MI, 48105, United States of America, zhazheng@umich.edu, Brian Denton, Xiaolan Xie

This study considers a chance constrained version of the stochastic extensible bin packing problem with applications to operating room (OR) scheduling. Surgeries are subject to random duration and surgery-to-OR allocation decisions are made to minimize the expected cost of overtime subject to probabilistic constraints on completion time that vary by OR. We describe a column generation approach tailored to this problem and we describe results based on instances of the problem for a large hospital-based surgical practice.

3 - Chance-constrained Surgery Planning under Uncertain or Ambiguous Surgery Durations

Yan Deng, University of Michigan, Ann Arbor, MI, 48109, United States of America, yandeng@umich.edu, Siqian Shen, Brian Denton

We study surgery planning problems with uncertain surgery durations and probabilistic constraints restricting risk of delays and overtime. We develop cutting-plane algorithms exploiting decomposable problem structure, and study distributionally robust model variants by assuming ambiguous distributional information. Computational experiments on real data reveal insights in surgery planning under data uncertainty/ambiguity.

ThD18

18- Sterlings 3

Nonconvex, Non-Lipschitz, and Sparse Optimization IV

Cluster: Nonlinear Programming

Invited Session

Chair: Xiaojun Chen, Professor, The Hong Kong Polytechnic University, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, xiaojun.chen@polyu.edu.hk

1 - Recovery of Sparse Vectors and Low-Rank Matrices via Partial Regularization

Zhaosong Lu, Associate Professor, Simon Fraser University, Department of Mathematics, Burnaby, Canada, zhaosong@sfu.ca

We propose a model for recovering sparse vectors and low-rank matrices via partial regularization that alleviates the bias of some nonzero components of sparse vector or nonzero singular values of low-rank matrices. We derive the null space and RIP recovery conditions that are weaker than those for the models using full regularization. Also, we propose a proximal gradient method to solve this model whose subproblem generally has a closed-form solution and can be efficiently solved. The global convergence of this method is also established. Numerical experiments show that the proposed approach is capable of recovering some sparse vectors and low-rank matrices that fail to be recovered by the existing models using full regularization.

2 - Composite L_q Minimization over Polyhedron

Ya-Feng Liu, Assistant Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, No. 55, ZhongGuanCun DongLu, Beijing, Beijing,100190, China, yafliu@lsec.cc.ac.cn, Shiqian Ma, Yu-Hong Dai, Shuzhong Zhang

The composite L_q minimization problem over a general polyhedron with q less than one has received various applications in machine learning, wireless communications, image restoration, signal reconstruction, etc. In this talk, we shall present a theoretical study on this problem. In particular, we shall study the computational complexity of the problem, derive the Karush-Kuhn-Tucker (KKT) optimality conditions for local minimizers of the problem, propose a smoothing sequential quadratic programming framework for solving the problem, and analyze the worst-case iteration complexity of the proposed framework.This is a joint work with Shiqian Ma, Yu-Hong Dai, and Shuzhong Zhang.

3 - A Structured Low Rank Matrix Penalty Method and Applications to Sensor Network

Tianxiang Liu, Chinese Academy of Sciences, No.55 East Zhongguancun Road, Haidian District, Beijing, China, liutx@lsec.cc.ac.cn, Zhaosong Lu, Xiaojun Chen, Yu-Hong Dai

This paper considers a matrix optimization problem where the objective function is continuously differentiable and the constraints involve a box constraint and a rank constraint. We penalize the rank constraint by a non-Lipschitz function and give sufficient conditions for the existence of exact penalty parameters regarding local minimizers and global minimizers. Moreover, we propose an efficient algorithm to solve the penalized problem and prove the convergence of the algorithm to a stationary point.

ThD19

19- Ft. Pitt

Combinatorial Optimization for Big Data Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Anand Srivastav, Professor, Kiel University / Department of Computer Science, Christian-Albrechts-Platz 4, Kiel, 24118, Germany, asr@numerik.uni-kiel.de

1 - Parallel Evolutionary Algorithms for Large Problems: Parameter Optimization and Hypergraph Coloring

Volkmar Sauerland, Research Associate, Kiel University / Department of Computer Science, Christian-Albrechts-Platz 4, Kiel, 24118, Germany, vsa@informatik.uni-kiel.de

We present a framework for parallel Estimation of Distribution Algorithms to tackle two applications. The first one is the estimation of the production of marine carbon dioxide in order to more precisely predict climate effects. The second one is the (practical) solution of a hypergraph coloring problem, which has been open for 20 years. We show with methods from Algorithm Engineering the experimental and also theoretical and partially also theoretical foundation of our Algorithms.

2 - External Memory Graph Algorithms

Ulrich Meyer, Professor, Goethe University Frankfurt am Main / Institute of Computer Science, Robert-Mayer-Strafle 11-15, Frankfurt am Main, 60325, Germany, umeyer@ae.cs.uni-frankfurt.de

Large graphs arise naturally in many real world applications. The actual performance of simple RAM model algorithms for traversing these graphs (stored in external memory) deviates significantly from their linear or near-linear predicted performance because of the large number of I/Os they incur. In order to alleviate the I/O bottleneck, many external memory graph traversal algorithms have been designed with provable worst-case guarantees. In the talk I highlight some techniques used in the design and engineering of such algorithms and survey the state-of-the-art in I/O-efficient graph traversal algorithms.

3 - Parallel Graph Partitioning for Complex Networks

Christian Schulz, Postdoctoral Researcher, Karlsruhe Institute of Technology (KIT) / Institute of Theoretical Informatics, Am Fasanengarten 5, Karlsruhe, 76131, Germany, christian.schulz@kit.edu, Henning Meyerhenke, Peter Sanders

To do parallel graph processing of social networks, we need to partition them into equally sized pieces. Previous parallel graph partitioners do not work well for these networks. We address this problem by parallelizing and adapting the label propagation technique developed for graph clustering. By introducing size constraints, label propagation becomes applicable for coarsening and refinement of multilevel partitioning. We obtain a high quality system that is also more scalable than state-of-the-art systems like ParMetis or PT-Scotch. On large networks the performance differences are very big. For example our algorithm partitions a web graph with 3.3G edges in 16 seconds using 512 cores of a HPC cluster producing a high quality partition.

ThD20

20- Smithfield

Recent Advances in Constrained Convex Minimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Volkan Cevher, Laboratory for Information and Inference Systems (LIONS), EPFL, Switzerland, EPFL STI IEL LIONS, ELE 233 (B,timent ELE) Station 11, Lausanne, 1015, Switzerland, volkan.cevher@epfl.ch

1 - Solving Convex Constrained Problems using Random Distributed Algorithms

Jean-Christophe Pesquet, University of Paris-Est, 5, Boulevard Descartes, Champs sur Marne, Marne la Vallee Cedex 2, 77454, France, jean-christophe.pesquet@u-pem.fr, Emilie Chouzenoux, Audrey Repetti

Relying on random block-coordinate primal-dual methods, we designe distributed algorithms for minimizing a sum of (non-)smooth convex functions involving linear operators. Distributed methods have the ability to deal with multi-agent problems where the performed updates are limited to a neighborhood of a small number of agents, the set of active agents being selected according to an arbitrary random rule. We prove the almost sure convergence of the iterates to a solution of the considered problem. When the non-smooth functions are chosen as indicator functions of convex sets, the proposed algorithms can be viewed as distributed versions of alternating projections onto convex sets techniques to solve constrained optimization problems.

2 - Solving Constrained and Non-Smooth Problems with Efficient Dual Techniques

Stephen Becker, Assistant Professor, University of Colorado Boulder, 526 UCB, University of Colorado, Boulder, CO, 80309, United States of America, Stephen.Becker@colorado.edu

Proximal methods are a recent trend in optimization. Of course, a major issue arises when it is not possible to compute the proximity operator efficiently. This happens in situations such as (1) composition with a linear operator, and/or (2) using a scaled metric, such as in a Newton or quasi-Newton method. We go over the solution proposed by TFOCS, which is to use the proximal point method and solve the dual. We also present recent work (joint with J. Fadili) on an alternative method to solve the prox, which can be used instead of, or in conjunction with, TFOCS. For some carefully designed quasi-Newton methods, the prox update can be done for essentially no extra cost over the gradient-descent case.

3 - Universal Primal-Dual Proximal-Gradient Methods

Alp Yurtsever, (LIONS), EPFL, Switzerland, Laboratory for Information and Inference, ELD 244 (B,timent ELD) Station 11, Lausanne, 1015, Switzerland, alp.yurtsever@epfl.ch, Quoc Tran-Dinh, Volkan Cevher

We propose a primal-dual algorithmic framework for a prototypical constrained convex minimization problem. The new framework aims to trade-off the computational difficulty between the primal and the dual subproblems. We achieve this in our setting by replacing the standard proximal mapping computations with linear minimization oracles in the primal space, which has been the hallmark of the scalable Frank-Wolfe type algorithms. Our analysis extends Nesterov's universal gradient methods to the primal-dual setting in a nontrivial fashion, and provides optimal convergence guarantees for the objective residual as well as the feasibility gap without having to know the smoothness structures of the problem.

ThD21

21-Birmingham

Stochastic and Nonsmooth Derivative-Free Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Rommel Regis, Associate Professor, Saint Joseph's University, Department of Mathematics, 5600 City Avenue, Philadelphia, PA, 19131, United States of America, rregis@sju.edu

1 - Trust Region-Based Optimization over Stochastic Simulations

Satyajith Amaran, Senior Engineer, The Dow Chemical Company, 2301 N Brazosport Blvd, Freeport, TX, 77541, United States of America, SAmaran@dow.com, Nikolaos Sahinidis

Simulation optimization involves the optimization over stochastic simulations such as discrete-event simulations and stochastic differential equation systems. We develop a provably convergent trust region-based method for continuous simulation optimization. In addition to providing formal convergence proofs, we demonstrate the practical use of the method through the description of an implementation, its success on a large test bed and two important applications, namely inventory optimization in chemical supply chains and optimal sizing of obstructions for DNA separation.

2 - Derivative-Free Optimization of Costly Simulators Taking Uncertain Values

Benoit Pauwels, PhD Student, IFP Energies Nouvelles and Université de Toulouse 3, 1&4 avenue de Bois-Préau, Rueil-Malmaison, France, Benoit.Pauwels@ifpen.fr, Serge Gratton, Frédéric Delbos

We consider the derivative-free optimization of costly simulators whose return values are uncertain. This uncertainty may result from noisy measures or ill-known model parameters in the definition of the objective function. We investigate methods taking into account stochastic uncertainty or subjective knowledge on the uncertainty. These have several applications in the energy industry such as oil wells placement or wind turbine design.

3 - Model-based Approaches for Nonsmooth Greybox Optimization

Stefan Wild, Argonne National Laboratory, 9700 S Cass Ave, 240-1151, Argonne, IL, 60439, United States of America, wild@anl.gov, Jeffrey Larson, Aswin Kannan, Matt Menickelly

We consider settings where an objective function is a nonsmooth function of simulation outputs, which are characterized by having smooth, but unavailable derivatives. We survey and propose a number of techniques based on forming smooth models of the simulation output, with each technique differing in its treatment of the nonsmoothness. Our analysis focuses on special cases, while our numerical study illustrates when these techniques are beneficial in practice.

ThD22

22- Heinz

Recent Enhancements in Solving Nonsmooth Optimization Problems

Cluster: Variational Analysis

Invited Session

Chair: Sandra Santos, University of Campinas, Rua Sergio Buarque de Holanda, 651,, Campinas, SP, Brazil, sandra@ime.unicamp.br

1 - Epsilon-Subgradient Algorithms for Bilevel Convex Optimization

Elias Helou, Professor, University of São Paulo, Avenida Trabalhador Sancarlense, 400, São Carlos, SP, 13562-180, Brazil, elias@icmc.usp.br, Lucas Simoes

We introduce and study the convergence properties of a new class of explicit epsilon-subgradient methods for the task of minimizing a convex function over the set of convexly-constrained minimizers of another convex function. The general algorithm specializes to some important cases, such as first-order methods applied to a varying objective function, which have computationally cheap iterations. We present numerical experimentation for certain cases where the theoretical framework encompasses efficient algorithmic techniques, with application of the resulting methods to very large practical problems arising in tomographic image reconstruction.

2 - Advantages of using Nonmonotone Line Search on Gradient Sampling with Adaptivity and LBFGS Technique

Lucas Simoes, State University of São Paulo, Rua Sèrgio Buarque de Holanda, Campinas, Brazil, simoes.lea@gmail.com, Sandra Santos, Elias Helou

The gradient sampling method has been gaining attention from the scientific community, mostly because of its intuitive ideas, associated with its good performance in challenging problems. Hence, many variations of the original method have been developed in the last decade, being the adaptive gradient sampling method with LBFGS approach an example. However, some issues involving the practical algorithms have not been solved yet. This study has the aim to supress the differentiability test in each iteration and to introduce a nonmonotone line search to avoid tiny step sizes during the execution of the algorithms. We also present some numerical results that corroborate the new procedures.

3 - String-Averaging of Subgradients: a New Method for Nonsmooth Constrained Convex Optimization

Rafael Oliveira, PhD Student, University of São Paulo, Avenida Trabalhador São-carlense, 400, São Carlos, SP, 13566-590, Brazil, rafaelzane@hotmail.com, Eduardo Costa, Elias Helou

We present a method for non-smooth convex minimization which is based on subgradient directions and string-averaging techniques. In this approach, the set of available data is split into sequences (strings) and a given iterate is processed independently along each string, possibly in parallel, by an incremental subgradient method (ISM). The end-points of all strings are averaged to form the next iterate. The method is useful to solve sparse and large-scale non-smooth convex optimization problems, such as those arising in tomographic imaging. A convergence analysis is provided and the numerical tests show good performance for the convergence speed when measured as the ratio of objective function decrease, in comparison to classical ISM.

■ ThD23

23- Allegheny

Combinatorial Optimization

Cluster: Combinatorial Optimization
Invited Session

Chair: Vincent Kreuzen, Maastricht University, Tongersestraat 53, Maastricht, Netherlands, v.kreuzen@maastrichtuniversity.nl

1 - Heuristics for the Stochastic Single-machine Problem with E/T Costs

Débora Ronconi, University of São Paulo, Av. Prof. Almeida Prado, 128, São Paulo, SP, 05017020, Brazil, dronconi@usp.br, Rafael Lemos

This paper addresses the problem of concurrent due-date assignment and sequencing of jobs on a stochastic single-machine environment with distinct job earliness and tardiness penalty costs. It is assumed that the jobs processing times are statistically independent and follow a normal distribution whose mean and variance are provided. Two insertion-based constructive heuristics are proposed to minimize the E/T costs. Numerical experiments were performed and, in the majority of the cases, the solutions found by the proposed heuristics had better costs than the solutions described in the literature. An extension of the problem with processing times modeled as lognormal random variables was also investigated and solved with good results.

2 - The Oil Tanker Problem

Vincent Kreuzen, Maastricht University, Tongersestraat 53, Maastricht, Netherlands, v.kreuzen@maastrichtuniversity.nl, Tim Oosterwijk, Alexander Grigoriev, MichaÎl Gabay

We study a variant of the single machine capacitated lot-sizing problem with sequence-dependent setup costs and product-dependent inventory costs. Given a single platform and a set of tankers associated with shore stations, each tanker is associated with a constant demand rate, maximum loading rate and holding costs per time unit. Docking and undocking incurs sequencing costs based on the types of tankers. We prove a number of structural properties for optimal schedules for the problem and present an algorithm which approximates the optimal solution.

3 - Total Dual Integrality of the Linear Complementarity Problem

Hanna Sumita, University of Tokyo, 7-3-1 Hongo Bunkyo-ku, Tokyo, 113-8656, Japan, Hanna_Sumita@mist.i.u-tokyo.ac.jp, Naonori Kakimura, Kazuhisa Makino

In this talk, we introduce total dual integrality of the linear complementarity problem (LCP) by analogy with the linear programming problem. The main idea of defining the notion is to propose the LCP with orientation, a variant of the LCP whose feasible complementary cones are specified by an additional input vector. This allows us to define naturally its dual problem and the total dual integrality of the LCP. We show that if the LCP is totally dual integral, then all basic solutions are integral. If the input matrix is sufficient or rank-symmetric, then this implies that the LCP always has an integral solution whenever it has a solution.

■ ThD24

24- Benedum

Theory and Computing for Mixed–Integer Nonlinear Optimization

Cluster: Mixed-Integer Nonlinear Programming
Invited Session

Chair: Ashutosh Mahajan, Assistant Professor, IIT Bombay, Powai, Mumbai, 400076, India, amahajan@iitb.ac.in

1 - Local Polyhedral Property of some Integer Hulls

Vishnu Narayanan, Assistant Professor, Indian Institute of Technology Bombay, Industrial Eng. and Operations Research, IIT Bombay, Powai, Mumbai, MH, 400 076, India, vishnu@iitb.ac.in, Umakanta Pattanayak

We study properties of convex hulls of integer points in the following classes of convex sets: nonrational polyhedra and strictly convex sets. Moussafir (2003) showed that for a class of nonrational polyhedra, the convex hull of integer points is locally polyhedral. We extend this result to a larger class, and give examples of nonrational polyhedra whose integer hulls are not locally polyhedral. We give sufficient conditions for strictly convex sets to have locally polyhedral integer hulls.

2 - MINLPLib 2.0

Stefan Vigerske, GAMS, P.O. Box 40 59, Frechen, 50216, Germany, svigerske@gams.com

Since 2001, the Mixed-Integer Nonlinear Programming Library (MINLPLib) and the GLOBAL Library (GLOBALLib) have provided algorithm developers with a varied set of both theoretical and practical (MI)NLP test models. In this presentation, we report on recent progress on extending, updating, and categorizing MINLPLib and GLOBALLib. We hope that the updated library can be a starting point to define a widely accepted test set to evaluate the performance of NLP and MINLP solving software.

3 - New Developments in Minotaur Toolkit

Ashutosh Mahajan, Assistant Professor, IIT Bombay, Powai, Mumbai, 400076, India, amahajan@iitb.ac.in

Minotaur is an open-source toolkit for implementing algorithms for solving MINLPs. Different components of this object oriented modular framework can be combined together to create fast solvers. We describe the latest developments in the toolkit. These include a faster LP-NLP algorithm for convex MINLPs, a multistart heuristic for global optimization and other improvements in interfaces and features.

■ ThD25

25- Board Room

Optmization in Energy Systems

Cluster: Optimization in Energy Systems
Invited Session

Chair: Siew Fang Woon, Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Sintok, Malaysia, woonsiewfang@yahoo.com

1 - AC Power Grid Design by Integer Linear Programming

Arie M.C.A. Koster, Professor, RWTH Aachen University, Lehrstuhl II für Mathematik, Aachen, 52056, Germany, koster@math2.rwth-aachen.de, Stephan Lemkens

As the AC power flow is given by nonconvex, nonlinear equations, designing a power grid implies either the solving of a mixed integer nonlinear optimization problem or refraining from optimality. Instead of the linear DC model, we study in this talk a Taylor-based linearization that also considers reactive flows. We derive valid inequalities, present computations, and show the superiority of this linearization for the power grid design problem, when considering AC feasibility.

2 - A MIP Framework for Non-Convex Uniform Price (European) Day-Ahead Electricity Auctions

Mehdi Madani, Louvain School of Management (Catholic University of Louvain), Place des Doyens 1 bte L2.01.01, Louvain-la-Neuve, 1348, Belgium, mehdi.madani@uclouvain.be, Mathieu Van Vyve

A new ‘primal-dual framework’ is provided (involving prices and quantities), which allow to consider algorithmic and economic issues of interest for European electricity market stakeholders, avoiding any auxiliary binary variables. Main characteristics of coupled European day-ahead markets are presented. We show how to use the framework to give an exact linearization of a non-convex ‘minimum income condition’ for producers, still without any auxiliary variables, or to minimize opportunity costs of so-called paradoxically rejected block bids.

3 - Chance Constrained Optimal Power Flow with Renewable Energy and Energy Storage

Jianqiang Cheng, Sandia National Laboratories, Quantitative Modeling & Analysis Dept, Sandia National Labs, 7011 East Avenue, Livermore, CA, United States of America, jianqiang.cheng@gmail.com, Habib Najm, Ali Pinar, Cosmin Safta, Jean-Paul Watson, Richard Chen

We consider a chance constrained optimal power flow (CCOPF) problem that integrates energy storage and uncertainty in renewable energy output and demand. Specifically, it is required that the probability that both supply-demand and the energy storage physical constraints are satisfied is close to 1. To solve this problem, an efficient partial sample average approximation (PSAA) is put forward. We will present computational results performed on IEEE test systems and how they compare to other methods.

■ ThD26

26- Forbes Room

MISP at ISMP: Mixed-Integer Stochastic Programming

Cluster: Stochastic Optimization

Invited Session

Chair: Maarten van der Vlerk, University of Groningen, Dept. of Operations, P.O. Box 800, Groningen, Netherlands, m.h.van.der.vlerk@rug.nl

1 - A Convex Approximation for Two-Stage Mixed-Integer Recourse Models

Ward Romeijnders, University of Groningen, Dept. of Operations, P.O. Box 800, Groningen, 9700AV, Netherlands, w.romeijnders@rug.nl, Ruediger Schultz, Maarten van der Vlerk, Wim Klein Haneveld

We derive a convex approximation for two-stage mixed-integer recourse models and we show that the error of this approximation vanishes as all total variations of the probability density functions of the random variables in the model decrease to zero. To prove this result we use asymptotic periodicity of the mixed-integer value function and error bounds on the expectation of periodic functions.

2 - Computational Considerations for Mixed Integer Variables in Both Stages

Suvrajeet Sen, Professor, University of Southern California, Industrial and Systems Eng., Los Angeles, CA, 90403, United States of America, s.sen@usc.edu, Semih Atakan

Mixed integer variables arise in both stages of many SMIP applications. These include two stage location-allocation, location-sizing-allocation, and many other classes. Unfortunately, standard Benders' decomposition does not apply here, and as a result, researchers often try to solve the deterministic equivalent formulation (DEF) using standard off-the-shelf MIP solvers. This approach is inadequate to the task when scenarios grow. In this presentation we give computational evidence that combining polyhedral combinatorics with SP decomposition provides the necessary tools for computations as well as mathematical convergence. Using desktops, we report optimal solutions for instances whose DEF contain millions of mixed-integer variables.

3 - Totally Unimodular Multistage Stochastic Programs

Ruichen Richard Sun, PhD Student, Univerisity of Pittsburgh, 1048 Benedum Hall, 3700 O'Hara Street, Pittsburgh, PA, 15261, United States of America, rus19@pitt.edu, Andrew J. Schaefer, Oleg V. Shylo

We consider totally unimodular multistage stochastic programs, that is, multistage stochastic programs whose extensive-form constraint matrices are totally unimodular. We establish several sufficient conditions and identify examples that have arisen in the literature.

ThD27

27- Duquesne Room

Network Design III

Cluster: Combinatorial Optimization

Invited Session

Chair: Laszlo Vegh, London School of Economics, Houghton Street, London, WC2A 2AE, United Kingdom, L.Vegh@lse.ac.uk

1 - On Approximate Precedence Constrained Deadline Scheduling & Network Diffusion

Jochen Koenemann, University of Waterloo, 200 University Avenue West, Waterloo, ON, Canada, jochen@uwaterloo.ca

We consider the classic problem of scheduling a set of n jobs non-preemptively on a single machine. Each job j has non-negative processing time, weight, and deadline, and a feasible schedule needs to be consistent with chain-like precedence constraints. The goal is to compute a feasible schedule that minimizes the sum of penalties of late jobs. Lenstra and Rinnoy Kan [Annals of Disc. Math., 1977] showed that the above problem is NP-hard. To the best of our knowledge, we are the first to study the approximability of this problem. We present an O(log k)-approximation for instances with k distinct job deadlines. We also show a nice connection of this problem to technology diffusion processes in networks.

2 - On Survivable Set Connectivity

Fabrizio Grandoni, Prof., IDSIA, Galleria 1, Manno, 6928, Switzerland, fabrizio@idsia.ch, Bundit Laekhanukit, Parinya Chalermsook

In the Survivable Set Connectivity problem (SSC) we are given an n-node edge-weighted undirected graph and a collection of h set pairs (S_i,T_i), where S_i and T_i are subsets of nodes. Each pair i has an integer connectivity requirement k_i>=1. Our goal is to compute a min-cost subgraph H so that there are at least k_i edge-disjoint paths in H between S_i and T_i for all i. We show that there is no poly-logarithmic approximation for SSC unless NP has a quasi-polynomial time algorithm. Furthermore, we present a bicriteria approximation algorithm for SSC that computes a solution H of cost at most poly-logarithmically larger than the optimal cost and provides a connectivity at least Omega(k_i/log n) for each set pair i.

3 - Degree-bounded Network Design with Node Connectivity Requirements

Alina Ene, Assistant Professor, University of Warwick, Department of Computer Science, Coventry, CV4 7AL, United Kingdom, A.Ene@warwick.ac.uk, Ali Vakilian

We consider degree bounded network design problems with element and vertex connectivity requirements. The input is an undirected graph G with weights on the edges and degree bounds b(v) on the vertices, and connectivity requirements for each pair of vertices. The goal is to select a minimum-weight subgraph of G that meets the connectivity requirements and it satisfies the degree bounds on the vertices. We give the first (O(1), O(1) b(v)) bicriteria approximation algorithms for the degree-bounded survivable network design problem with element connectivity requirements and for several problems with vertex connectivity requirements.

■ ThD28

28- Liberty Room

Interdiction Models in Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Juan Sebastian Borrero, University of Pittsburgh, 1048 Benedum Hall, PIttsburgh, PA, 15261, United States of America, jsb81@pitt.edu

1 - Critical Nodes in Network Cohesion

Alexander Veremyev, University of Florida, 303 Weil Hall, Gainesville, FL, United States of America, averemyev@ufl.edu, Oleg Prokopyev, Eduardo Pasiliao

In this talk we consider a class of critical nodes detection problems that involves minimization of the cohesiveness (communication efficiency) of a given unweighted graph via the removal of a subset of nodes subject to a budgetary constraint. The communication efficiency of a graph is assumed to be a general distance-based metric (e.g., graph efficiency or harmonic average geodesic distance, Harary index, characteristic path length, communication utility) that depends on the actual pairwise distances between nodes in the remaining graph. We derive linear integer programming (IP) formulations along with additional enhancements, and develop an exact iterative algorithm aimed at improving the performance of standard solvers.

2 - Detecting Critical Vertex Structures on Graphs: A Mathematical Programming Approach

Jose Walteros, Assistant Professor, University at Buffalo, 413 Bell Hall, Buffalo, NY, 14260, United States of America, josewalt@buffalo.edu, Alexander Veremyev, Eduardo Pasiliao, Panos Pardalos

We consider the problem of detecting a collection of critical vertex structures of a graph, whose deletion optimally deteriorates the connectivity of the graph. The principal objective of the proposed approach is to generalize other models existing in the literature, whose scope is restricted to removing individual and unrelated vertices. We focus our attention on the cases where the vertex structures form cliques or stars, albeit the proposed technique is general enough to be easily extended for detecting other kinds of critical structures.

3 - Sequential Shortest Path Network Interdiction with Incomplete Information

Juan Sebastian Borrero, University of Pittsburgh, 1048 Benedum Hall, PIttsburgh, PA, 15261, United States of America, jsb81@pitt.edu, Oleg Prokopyev, Denis Saure

We study sequential interdiction of evaders on a network when the interdictor has partial initial information about the network structure and costs. In each period, the interdictor removes up to k arcs from the network, after which an evader travels a shortest path. By observing the evaders' actions the interdictor learns about the arcs and costs of the network and adjusts its actions accordingly. We analyze a class of policies that remove a set of k-most vital arcs of the observed network, and assess its optimality.

■ ThD29

29- Commonwealth 1

New Trends in First Order Methods for Non-smooth Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Thomas Pock, Graz University of Technology, Inffeldgasse 16, Graz, 8010, Austria, pock@icg.tugraz.at

1 - iPiano: Inertial Proximal Algorithm for Nonconvex Optimization

Peter Ochs, University of Freiburg, ochs@cs.uni-freiburg.de, Yunjin Chen, Thomas Brox, Thomas Pock

We study an algorithm for solving a minimization problem composed of a differentiable (possibly nonconvex) and a simple (possibly nondifferentiable and nonconex) function. The algorithm iPiano combines forward-backward splitting with an inertial force. It can be seen as a nonsmooth split version of the Heavy-ball method from Polyak. A rigorous analysis of the algorithm for the proposed class of problems yields global convergence of the function values and the arguments. This makes the algorithm robust for usage on nonconvex problems. The convergence result is obtained based on the Kurdyka-Lojasiewicz inequality.

2 - Extensions of the PDHGM

Tuomo Valkonen, DAMTP, University of Cambridge, Wilberforce Road, Cambridge, CB3 0WA, United Kingdom, tjmv3@cam.ac.uk

The Chambolle-Pock method or PDHGM (primal-dual hybrid gradient method, modified) has been very succesfull in image processing. It has recently been extended, by the speaker and others, from its original convex optimisation setting also to non-convex problems, such as inverse problems involving non-linear forward operators. In this talk, I will speak about these algorithms, and how their analysis helps to further study the original method, and to possibly derive improved acceleration schemes.

3 - On the Convergence of the Iterates of Accelerated Descent Methods

Antonin Chambolle, Prof., CMAP, Ecole Polytechnique & CNRS, Ecole Polytechnique, Palaiseau, 91128, France, antonin.chambolle@cmap.polytechnique.fr

Based on the standard convergence theory for over-relaxed and inertial descent algorithms, we are able to show that a slight modification of the "FISTA" descent rule (Beck and Teboulle, 2008) yields a converging sequence of iterates, without changing the overall accelerated rate of decay of the energy (only the constant is slightly affected). This is a joint work with Charles Dossal from Univ. Bordeaux-1.

■ ThD30

30- Commonwealth 2

Approximation and Online Algorithms XI

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Dorit S. Hochbaum, Professor, University of California, Berkeley, Etcheverry Hall, Berkeley, CA, 94720, United States of America, hochbaum@ieor.berkeley.edu

1 - Online Submodular Welfare Maximization: Greedy Beats 1/2

Morteza Zadimoghaddam, Research Scientist, Google Research, 76 9th Ave, New York, NY, 10011, United States of America, zadim@google.com, Vahab Mirrokni, Nitish Korula

In the Online Submodular Welfare Maximization (SWM) problem, the input consists of a stream of n items arriving one at a time. The algorithm must make an irrevocable decision about which of the m agents to assign the just arrived item to before seeing the subsequent items. Each agent has a monotone submodular valuation function for the set of items she receives. The goal is to assign items while maximizing the social welfare, defined as the sum of valuations of all agents. We prove that a simple greedy algorithm is (1/2+Omega(1))-competitive if the items arrive in a random order. We also formulate a natural conjecture which, if true, would improve the competitive ratio of the greedy algorithm to at least 0.567.

2 - The Submodular Joint Replenishment Problem

Adam Elmachtoub, IBM Research, 1101 Kitchawan Rd., Yorktown Heights, NY, United States of America, adam@ieor.columbia.edu, Retsef Levi, Maurice Cheung, David Shmoys

The joint replenishment problem (JRP) is a multi-item inventory model that captures the tradeoff between replenishing inventory frequently versus holding lots of inventory to satisfy time-dependent, deterministic demands. Moreover, the JRP captures the economies of scale in replenishing multiple item types simultaneously. Historically, the joint replenishment cost has a simple additive structure. We generalize the joint replenishment cost to be a submodular function over the item types, and provide approximation algorithms under various settings.

3 - Approximation Algorithms for Submodular Minimization Problems

Dorit S. Hochbaum, Professor, University of California, Berkeley, Etcheverry Hall, Berkeley, CA, 94720, United States of America, hochbaum@ieor.berkeley.edu

We show that submodular minimization (SM) problems subject to constraints containing up to two variables per inequality are 2-approximable in polynomial time. When the coefficients of the two variables in each constraint are of opposite signs (monotone constraints) then the SM minimization or supermodular maximization is polynomial time solvable. The 2-approximable problems include: SM-vertex cover; SM-2SAT: SM-min satisfiability; SM-edge deletion for clique, SM-node deletion for biclique and others. These 2-approximations are best possible unless NP=P. We show that SM minimization on totally unimodular constraints is an NP-hard problem, but SM minimization over monotone constraints is solved in polynomial time.

Thursday, 4:35pm - 5:25pm

■ ThE01

01- Grand 1

On Mathematical Programming with Indicator Constraints

Cluster: Plenary

Invited Session

Chair: Egon Balas, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA 15213, United States of America, eb17@andrew.cmu.edu

1 - On Mathematical Programming with Indicator Constraints

Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

In this paper we review the relevant literature on mathematical optimization with logical implications, i.e., where constraints can be either active or disabled depending on logical conditions to hold. In the case of convex functions, the theory of disjunctive programming allows one to formulate these logical implications as convex nonlinear programming problems in a space of variables lifted with respect to its original dimension. We concentrate on the attempt of avoiding the issue of dealing with large NLPs. In particular, we review some existing results that allow to work in the original space of variables for two relevant special cases where the disjunctions corresponding to the logical

implications have two terms. Then, we significantly extend these special cases in two different directions, one involving more general convex sets and the other with disjunctions involving three terms. Computational experiments comparing disjunctive programming formulations in the original space of variables with straightforward bigM ones show that the former are computationally viable and promising. (Joint work with Pierre Bonami, Andrea Tramontani and Sven Wiese).

■ ThE02

02- Grand 2

Quasi-Monte Carlo Methods for Linear Two-Stage Stochastic Programming Problems

Cluster: Plenary

Invited Session

Chair: Ignacio Grossmann, R. Dean University, Professor, Carnegie Mellon University, Doherty Hall, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, grossmann@cmu.edu

1 - Quasi-Monte Carlo Methods for Linear Two-Stage Stochastic Programming Problems

Werner Roemisch, Humboldt University, Berlin, Germany, romisch@math.hu-berlin.de

Quasi-Monte Carlo algorithms are studied for generating scenarios to solve two-stage linear stochastic programming problems. Their integrands are piecewise linear-quadratic, but do not belong to the function spaces considered for QMC error analysis. We show that under some weak geometric condition on the two-stage model all terms of their ANOVA decomposition, except the one of highest order, are continuously differentiable and second order mixed derivatives exist almost everywhere and belong to L_{2}. This implies that randomly shifted lattice rules may achieve the optimal rate of convergence $O(n^{-1+\delta})$ with $\delta\in(0,\frac{1}{2})$ and a constant not depending on the dimension if the effective superposition dimension is less than or equal to two. The geometric condition is shown to be satisfied for almost all covariance matrices if the underlying probability distribution is normal. We discuss effective dimensions and techniques for dimension reduction. Numerical experiments for a production planning model with normal inputs show that indeed convergence rates close to the optimal rate are achieved when using randomly shifted lattice rules or scrambled Sobol' point sets accompanied with principal component analysis for dimension reduction.

Thursday, 5:30pm - 7:00pm

■ ThF01

01- Grand 1

Complementarity/Variational Inequality VI

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Todd Munson, Argonne National Laboratory, Argonne, IL, 60439, United States of America, tmunson@mcs.anl.gov

1 - Complementarity Models for Traffic Equilibrium with Ridesharing

Huayu (Cathy) Xu, PhD, University of Southern California, 3715 McClintock Avenue, GER 240, Los Angeles, CA, 90089, United States of America, huayuxu@usc.edu, Jong Shi Pang, Fernando Ordòñez, Maged Dessouky

Ridesharing is an efficient way to utilize unused vehicle capacity and reduce traffic congestion, and it has recently become popular due to new communication technologies. The objective of this paper is to analyze how ridesharing impacts traffic congestion and how people can be motivated to participate in ridesharing, and conversely, how congestion influences ridesharing activities. We propose a new traffic equilibrium model with ridesharing, and formulate it as a mixed complementarity problem (MiCP). It is proved under meaningful conditions on the model parameters that there exists one and only one solution to this model. The KNITRO solver is adopted to solve the MiCP and the computational results are promising.

2 - Pricing Schemes for Two-Stage Market Clearing Model in Electricity Markets

Jinye Zhao, ISO New England, One Sullivan Rd, Holyoke, MA, 01040, United States of America, JZhao@iso-ne.com

To keep up with the growth of renewable resources, alternative dispatch mechanisms based on two-stage models, such as stochastic programming and look-ahead problems, have been extensively explored in electricity markets. However, little attention has been paid to the pricing issue. In this talk, two alternative pricing schemes are proposed for two-stage models. Under the first scheme, the 1st-stage decision is settled at a marginal clearing price which contains all future information while the 2nd-stage decision is compensated in the pay-as-bid fashion. Under the second scheme, both the 1st and 2nd stage decisions are settled at marginal prices which reflect partial future information. The pros and cons of both schemes are discussed.

3 - Phase Retrieval and Nash Games

Todd Munson, Argonne National Laboratory, Argonne, IL, 60439, United States of America, tmunson@mcs.anl.gov, Stefan Wild, Ashish Tripathi, Sven Leyffer

Coherent x-ray diffractive imaging is a technique that utilizes phase retrieval and nonlinear optimization to image matter at nanometer scales. Algorithms for the nonconvex phase retrieval problem can be written as a two player Nash game where the players choose the variables inside and outside the support, respectively. A Gauss-Jacobi algorithm for solving the game is discussed where each player chooses a descent direction for their individual optimization problem and then a two-variable complementarity problem is solved to obtain the step lengths. Numerical results for this algorithm on phase retrieval problems are provided.

■ ThF02

02- Grand 2

Conic Optimization: From Fundamental Limitations to Algorithmic Developments

Cluster: Conic Programming

Invited Session

Chair: João Gouveia, University of Coimbra, Apartado 3008 EC Santa Cruz, Coimbra, 3001-501, Portugal, jgouveia@mat.uc.pt

Co-Chair: Hamza Fawzi, MIT, hfawzi@mit.edu

Co-Chair: James Saunderson, Massachusetts Institute of Technology, 77 Massachusetts Ave, 32-D572, Cambridge, MA, 02139, United States of America, jamess@mit.edu

1 - Equivariant Semidefinite Lifts and Sum-of-Squares Hierarchies

Hamza Fawzi, MIT, hfawzi@mit.edu, James Saunderson, Pablo Parrilo

A positive semidefinite lift (psd lift) of a polytope P is a representation of P as the projection of an affine slice of the positive semidefinite cone. In this work we consider equivariant psd lifts, which are psd lifts that respect the symmetries of a polytope P. We present a representation-theoretic framework to study equivariant psd lifts of a certain class of symmetric polytopes known as regular orbitopes. Our main result is a structure theorem that establishes a connection between equivariant psd lifts and sum-of-squares lifts. We apply our framework to get lower bounds as well as constructions of equivariant psd lifts for certain well-known symmetric polytopes such as regular polygons, parity polytopes and cut polytopes.

2 - PSD Minimality and Polytope Ideals

Joào Gouveia, University of Coimbra, Apartado 3008 EC Santa Cruz, Coimbra, 3001-501, Portugal, jgouveia@mat.uc.pt, Kanstantsin Pashkovich, Richard Robinson, Rekha Thomas

A d-polytope is said to be psd minimal if it can be written as a projection of a slice of the cone of d+1 by d+1 positive semidefinite matrices, the smallest possible size for which this may happen. In this talk, we will introduce the concept of polytope ideal, an algebraic object that codifies the geometry of a polytope, and use it to derive obstructions and sufficient conditions for psd minimality. These will allow us to complete the classification of psd minimal 4-polytopes, providing examples that settle some open questions.

3 - A Polynomial-Time Affine-Scaling Method for Semidefinite and Hyperbolic Programming

Mutiara Sondjaja, New York University, 251 Mercer St., New York, NY, 10012, United States of America, sondjaja@cims.nyu.edu, James Renegar

We develop a natural variant of Dikin's affine-scaling method, first for semidefinite programming and then for hyperbolic programming in general. We match the best complexity bounds known for interior-point methods. All previous polynomial-time affine-scaling algorithms have been for conic optimization problems in which the underlying cone is symmetric. Hyperbolicity cones, however, need not be symmetric. Our algorithm is the first polynomial-time affine-scaling method not relying on symmetry.

ThF03

03- Grand 3

Strengths and Limits of Linear Programming Formulations

Cluster: Combinatorial Optimization

Invited Session

Chair: Yuri Faenza, EPFL SB MATH AA MA C1 573 Station 8 CH-1, Station 8, Lausanne, Switzerland, yuri.faenza@epfl.ch

1 - Effectiveness of Sparse Cutting-planes for Integer Programs with Sparse Constraints

Santanu Dey, Associate Professor, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, United States of America, santanu.dey@isye.gatech.edu, Qianyi Wang, Marco Molinaro

Many practical integer programming instances have sparse constraints. Consequently, many effective cutting-plane classes are sparse. State-of-the-art IP solvers prefer use of sparse cutting-planes due to performance of LP solvers. Motivated by these considerations, we theoretically study the strength of cutting-planes whose support is restricted to the support of the constraints in the constraint matrix. Additionally, this study helps in developing new approximation algorithms with better performance guarantees for some classes of stochastic IPs.

2 - Extended Formulation Lower Bounds via Hypergraph Coloring?

Stavros Kolliopoulos, Professor, Department of Informatics and Telecommunications, University of Athens, Panepistimiopolis, Panepistimiopolis, Ilissia, Athens, 157 84, Greece, sgk@di.uoa.gr, Yannis Moysoglou

We propose a framework for proving lower bounds on the size of extended formulations. We do so by introducing a specific type of extended relaxations that we call product relaxations and is motivated by the study of the Sherali-Adams hierarchy. We show that for every approximate relaxation of a zero-one polytope P, there is a product relaxation that has the same size and is at least as strong. We provide a methodology for proving lower bounds on the size of approximate product relaxations by lower bounding the chromatic number of an underlying hypergraph, whose vertices correspond to gap-inducing vectors. An application of the method to the capacitated facility location polytope is presented.

3 - Extended Formulations Based on Composition Rules

Kanstantsin Pashkovich, University of Waterloo, Waterloo, Canada, kanstantsin.pashkovich@gmail.com, Michele Conforti

This talk is dedicated to extended formulations of combinatorial polytopes which arise from “smaller” polytopes via some composition rule. We present known extended formulations of this type. In particular, we describe the framework developed by Margot (1994) for iterative construction of extended formulations and establish connections to other existing frameworks for constructing extended formulations. We also study the properties of polytopes, which are compatible with the framework of Margot.

ThF04

04- Grand 4

Conic Programming Algorithms and Applications

Cluster: Conic Programming

Invited Session

Chair: Kim-Chuan Toh, Professor, National University of Singapore, Department of Mathematics, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, mattohkc@nus.edu.sg

1 - A Numerical Study on the SOS Relaxation for a Lagrangian Relaxation of QOPs with Binary Variables

Sunyoung Kim, Professor, Ewha W. University, 11-1 Dahyun-dong, Sudaemoongu, Seoul, 120-750, Korea, Republic of, skim@ewha.ac.kr, Masakazu Kojima

We consider a Lagrangian relaxation of the QOPs whose convergence depends on a single Lagrangian parameter, and then studies its sum-of-squares (SOS) relaxation using numerical experiments. We show that the SOS relaxation attains the same optimal value as the Lagrangian relaxation for randomly generated QOPs. We also discuss a special class of QOPs whose optimal values cannot be obtained by the SOS relaxation.

2 - An Inexact Majorized Multi-block ADMM for a Class of Large-scale Convex Composite Programming

Kim-Chuan Toh, Professor, National University of Singapore, Department of Mathematics, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, mattohkc@nus.edu.sg

We design an inexact ADMM-type method for solving a class of large-scale linearly constrained multi-block convex composite minimization problems. We design majorized convex functions with appropriate proximal terms to construct subproblems that can be solved by a recently proposed symmetric block Gauss-Seidel (SBGS) technique, and some implementable inexact minimization criteria for solving the subproblems within the SBGS iterations. We establish the global convergence as well as some iteration-complexity results for the proposed method where the step-length can be chosen up to 1.618. Numerical results on a variety of high-dimensional quadratic SDP problems are also provided to show the efficiency of the proposed method.

3 - Unified Binary Classification Algorithm based on Practical Accelerated Proximal Gradient Methods

Naoki Ito, PhD Student, Keio University, Department of Administration Engineering, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama, 223-8522, Japan, pico@keio.jp, Akiko Takeda, Kim-Chuan Toh

Binary classification is the problem of predicting the class a given sample belongs to. It is important to find suitable classification models for given datasets in order to achieve good prediction performances. We design an efficient algorithm for solving a unified problem for various classification models, which speeds up the process of finding the best model. It is based on an accelerated proximal gradient method and performs better than specialized lgorithms designed for specific models.

ThF05

05- Kings Garden 1

Nonconvex, Non-Lipschitz, and Sparse Optimization V

Cluster: Nonlinear Programming

Invited Session

Chair: Xiaojun Chen, Professor, The Hong Kong Polytechnic University, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, xiaojun.chen@polyu.edu.hk

1 - An Improved Algorithm for the L2-Lp Minimization Problem

Simai He, Professor, Shanghai University of Finance and Economics, School of Information Mgt and Eng, Wudong Road, 100, Yangpu District, Shanghai, China, simaihe@mail.shufe.edu.cn, Dongdong Ge, Rongchuan He

In this work, we propose an iterative algorithm that finds approximate KKT point within polynomial time, for a class of non-Lipschitz and non-convex minimization problems. Same results are also generalized to problems with general linear constraints under mild conditions.

2 - Efficient Smoothing Method for Box Constrained Nonsmooth Nonconvex Optimization

Chao Zhang, Dr., Beijing Jiaotong University, Department of Applied Mathematics, Beijing, 100044, China, zc.njtu@163.com, Xiaojun Chen

In this paper, we develop efficient smoothing method to solve box constrained nonsmooth nonconvex minimization problems, which is flexible to enroll various existing algorithms for smooth optimization. We show the convergence of our method to stationary point under mild conditions. Numerical experiments are given to illustrate the efficiency of our smoothing method for solving nonsmooth nonconvex box constrained minimization problems of large size.

3 - Optimal Beamformer Design in Reverberant Environment

Zhibao Li, Post Doc, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, No. 55, ZhongGuanCun East Road, Beijing, China, zbli0307@163.com, Yu-Hong Dai

In this paper, we consider the optimal beamformer design problem, i.e., the joint group delay and beamformer design problem. We introduce a new variable to represent the group delay and formulate the joint group delay and beamformer design problem as a structured constrained convex optimization (SCCO) problem. Moreover, we exploit the separable structures of the SCCO problem and propose to use the alternating direction method of multipliers (ADMM) to solve it. Numerical simulation results show the effectiveness of the proposed method in the reverberant environment by comparing it with the LCMV method.

■ ThF06

06- Kings Garden 2

Advances in Integer Programming IX

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - Faster Solution of Semidefinite Relaxations for Non-Convex Quadratic Integer Programs

Maribel Montenegro, Technische Universitaet Dortmund, Vogelpothsweg 87, Dortmund, 44227, Germany, maribel.montenegro@math.tu-dortmund.de, Angelika Wiegele, Christoph Buchheim

We discuss different techniques for improving Q-MIST, a branch-and-bound approach for solving non-convex quadratic integer optimization problems. Q-MIST uses an interior point method at each node of the B&B tree to solve the semidefinite programming relaxations of such problems. We present two alternative methods that both try to exploit the specific problem structure, namely a small total number of active constraints and very sparse constraint matrices. In the first approach, we reformulate the semidefinite problem as a quadratic problem through low-rank factorization. The second approach works on the dual of the semidefinite relaxation, we solve it using a coordinate descent method with exact line search in order to compute dual bounds.

2 - Deciding Emptiness of the Gomory-Chvatal Closure is NP-Complete

Yanjun Li, Professor, Purdue University, 403 West State Street, West Lafayette, IN, 47907, United States of America, li14@purdue.edu, Gerard Cornuejols

The Gomory-Chvatal cuts are a prominent class of cutting planes for integer programs. The Gomory-Chvatal closure of a polyhedron is the intersection of all half spaces defined by its Gomory-Chvatal cuts. We show that it is NP-complete to decide whether the Gomory-Chvatal closure of a polyhedron is empty.

3 - A Linear Programming Approach to Inverse Mixed-Integer Programming

Jourdain Lamperski, Researcher, University Of Pittsburgh, 3700 O'Hara St., Pittsburgh, PA, 15261, United States of America, jbl22@pitt.edu, Andrew J. Schaefer

Given a feasible solution and "target objective" to a mixed-integer program (MIP), the inverse MIP problem is to find an objective such that the given feasible solution is optimal, and the distance from the target objective is minimized. Algorithms for solving inverse MIPs are known, but the structure of the problem remains an open question. By using the superadditive dual of the MIP, we formulate the inverse MIP problem as an exponentially large linear program.

■ ThF07

07- Kings Garden 3

Dealing with Nonlinearities using the Example of Gas Networks

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Alexander Martin, FAU Erlangen-Nürnberg, Department Mathematik, Cauerstr 11, Erlangen, Germany, alexander.martin@math.uni-erlangen.de

1 - Network Flow Theory for Natural Gas Transportation

Martin Grofl, TU Berlin, Strafle des 17. Juni 136, Fak. II, Mathematik, Sekr. MA 5-2, Berlin, 10623, Germany, gross@math.tu-berlin.de, Martin Skutella, Marc Pfetsch

We study the use of network flow theory for natural gas networks. Natural gas is an important energy source and is being used for over 20% of the world's electricity generation. Transportation requires the use of pipeline networks, which incorporate several types of control mechanisms in order to adapt to different usage scenarios. Tasks here include identifying feasible usage scenarios and finding control settings for their realization. We discuss a model that adapts classical network flow theory for this purpose. This requires handling binary decisions for controls, and the non-linear dependencies of flow on pressure.

2 - Optimal Layout of Gas Pipeline Networks

Robert Schwarz, Zuse Institute Berlin, Takustrafle 7, Berlin, Germany, schwarz@zib.de

We consider the problem of designing a network of pipelines to transport gas from multiple sources to sinks. It can be shown that cost-minimal networks do not contain cycles. We therefore restrict our search to Steiner trees. In addition to the topology, we also need to choose positions for the Steiner nodes and diameters on the pipeline segments. This is formulated as non-convex MINLP model, with a convex reformulation for any fixed topology.

3 - Computational Comparison of MIP and MINLP Models for Compressor Stations

Tom Walther, Konrad Zuse Institute, Takustrasse 7, Berlin, 14195, Germany, walther@zib.de, Benjamin Hiller

Compressor stations are the most complex parts of gas transmission networks. Proper modelling of their technical capabilities is crucial for efficiently running and planning gas networks. Mathematically, they are also a source of hard MINLP models since the operating range of a single compressor is a nonconvex set and several compressors may be used together in many combinatorial ways. We study models for complex compressor stations based on several models for a single compressor that have been proposed in the literature. We perform a computational comparison of those models, investigating their runtime/accuracy tradeoff.

■ ThF08

08- Kings Garden 4

Large-Scale First-Order Optimization Methods

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Mark Schmidt, University of British Columbia, 201 2366 Main Mall, Vancouver, Canada, schmidtmarkw@gmail.com

1 - Communication-Efficient Distributed Dual Coordinate Ascent

Martin Jaggi, ETH Zürich, Universitaetsstr 6, Zürich, 8092, Switzerland, m.jaggi@gmail.com, Virginia Smith, Martin Takac, Jonathan Terhorst, Sanjay Krishnan, Thomas Hofmann, Michael I Jordan

Communication remains the most significant bottleneck in the performance of distributed optimization algorithms for large-scale machine learning. We propose a communication-efficient framework, COCOA, that uses local computation in a primal-dual setting to dramatically reduce the amount of necessary communication. We provide a strong convergence rate analysis for this class of algorithms, as well as experiments on real-world distributed datasets with implementations in Spark. In our experiments, we find that as compared to state-of-the-art mini-batch versions of SGD and SDCA algorithms, COCOA converges to the same .001-accurate solution quality on average 25x as quickly.

2 - Accelerated Communication-Efficient Distributed Dual Coordinate Ascent

Martin Takac, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, United States of America, martin.taki@gmail.com, Chenxin Ma

We explore Nesterov acceleration techniques in distributed settings. We partition the data describing objective function across K nodes (computers) and on each of them we define a local optimization problem. We assume that the local problem is solved by any optimization method which can deliver some prescribed accuracy. In each iteration the approximate solutions are aggregated and a new iterate is obtained. We provide the iteration complexity of given framework and also discuss the computation vs. communication trade-off.

3 - Learning Sparsely used Overcomplete Dictionaries

Alekh Agarwal, Microsoft Research, 641 Avenue of the Americas, New York, NY, 10011, United States of America, alekha@microsoft.com

We consider the problem of learning sparsely used overcomplete dictionaries, where each observation consists of a sparse combination of the mutually incoherent dictionary elements. Our method consists of a clustering-based initialization step that gives a reasonably accurate initial estimate of the true dictionary. This estimate is further improved via an iterative algorithm which alternates between estimating the dictionary and coefficients. We establish that, under a set of sufficient conditions, our method converges at a linear rate to the true dictionary as well as the true coefficients for each observation. [[Joint work with Anima Anandkumar, Prateek Jain, Praneeth Netrapalli and Rashish Tandon]].

ThF09

09- Kings Garden 5

Applications of Robust Optimization

Cluster: Robust Optimization

Invited Session

Chair: Chrysanthos Gounaris, Assistant Professor, Carnegie Mellon University, DH3107, 5000, Forbes Ave., Pittsburgh, PA, 15213, United States of America, gounaris@cmu.edu

1 - Stochastic Robust Multi-Echelon Inventory Control based on Data Analytics

Cong Cheng, Institute of Industrial Engineering and Logistics Optimization, Northeastern University, Shenyang, 110819, China, chc_5588@163.com, Lixin Tang

In this paper, we address the multi echelon inventory problem based on the data analytics. The muiti-echelon inventory extracted from practical iron and steel enterprises has many features: logistics delay, stochastic demand, and the production process is a gray box, which are hard to represent by the traditional model, but one has plenty historical data. The probabilistic arguments for this problem relyed on historical data are provided. The stochastic robust model is build and a new trust region algorithm based on data is proposed to handle this problem, where each subproblem is reduced to a conic program.

2 - Robust Geometry Optimization in Elastodynamics with Time-Dependent Uncertainties

Philip Kolvenbach, Technische Universitaet Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, kolvenbach@mathematik.tu-darmstadt.de, Stefan Ulbrich

We consider the robust geometry optimization of load-carrying structures that are governed by the wave equation of elastodynamics and are subject to uncertain time-dependent parameters. We use a first-order approximation for the worst-case functions and assume the perturbations are restricted to an ellipsoidal or cylinder-like uncertainty set. The FEM-discretized geometry is subdivided such that the geometry transformation is piecewise affine and the system matrices can be assembled and differentiated efficiently. We present numerical results.

3 - Adjustable Robust Optimization of Process Scheduling under Uncertainty

Chrysanthos Gounaris, Assistant Professor, Carnegie Mellon University, DH3107, 5000, Forbes Ave., Pittsburgh, PA, 15213, United States of America, gounaris@cmu.edu, Nikolaos Lappas

We develop an Adjustable Robust Optimization (ARO) framework to address uncertainty in the parameters of Process Scheduling models. Unlike the traditional RO approach, which results in a static, “here-and-now” solution, ARO results in a solution policy that is a function of parameter realizations. We discuss the derivation of the ARO counterpart in this context, and we propose decision-dependent uncertainty sets to enforce that the policy depends only on observable realizations. Our results show that the ARO approach provides robust solutions that are considerably less conservative. In addition, we show that ARO can provide feasible solutions to instances with “zero-wait” task restrictions for which a traditional approach inherently cannot.

ThF10

10- Kings Terrace

Real-Time Optimization and Predictive Control II

Cluster: Nonlinear Programming

Invited Session

Chair: Lorenz T. Biegler, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, lb01@andrew.cmu.edu

1 - Parallel Cyclic Reduction Strategies for Dynamic Optimization

Bethany Nicholson, Carnegie Mellon University, United States of America, blnichol@andrew.cmu.edu, Lorenz Biegler, Shivakumar Kameswaran

Direct Transcription is a well-established method to solve dynamic optimization / optimal control problems efficiently. However, for problems with thousands of state variables and discretization points, the linear systems resulting from the Newton step comprise the dominant computational cost and become prohibitively expensive to solve. In this talk we discuss ways to exploit the inherent structure and sparsity of these linear systems, and employ parallel cyclic reduction strategies to solve them efficiently.

2 - An Interior-Point Decomposition Strategy for Parallel Solution of Dynamic Optimization Problems

Carl Laird, School of Chemical Engineering, Purdue University, 480 Stadium Mall Drive, West Lafayette, IN, United States of America, lairdc@purdue.edu, Yankai Cao, Jose Santiago Rodriguez

An efficient strategy for solution of DAE constrained optimization problems is to apply a direct transcription approach and solve the resulting large-scale nonlinear program. Here, we present a parallel decomposition strategy for these problems based on decomposition of the KKT system arising in nonlinear interior-point methods. This approach shows speedups of over 50 times on some problems.

3 - Robust NLP Formulations for Nonlinear Model Predictive Control (NMPC)

Devin Griffith, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, dwgriffi@andrew.cmu.edu, Xue Yang, Lorenz Biegler

Modern NLP solvers enable fast NMPC strategies for control of challenging nonlinear processes. However, dynamic systems have been reported where standard NMPC strategies have zero robustness. Guided by well-known sufficient KKT conditions and constraint qualifications, we develop and reformulate ideal, advanced step and advanced multi-step NMPC strategies that guarantee robust stability properties for general dynamic systems. We also demonstrate how these formulations overcome robustness limitations on three pathological examples from the literature.

ThF11

11- Brigade

Network Flows

Cluster: Combinatorial Optimization

Invited Session

Chair: Andreas Karrenbauer, Max Planck Institute for Informatics, Campus E1 4, Saarbruecken, 66123, Germany, andreas.karrenbauer@mpi-inf.mpg.de

1 - A Simple Efficient Interior Point Method for Min-Cost Flow

Ruben Becker, Max Planck Institute for Informatics, Campus E 1.4, Saarbruecken, 66123, Germany, ruben.becker@mpi-inf.mpg.de, Andreas Karrenbauer

In recent years, methods for computing network flows at the same time became asymptotically faster and also more and more involved. Since the underlying ideas of the new techniques originate from convex optimization (most notably interior point methods), rather than from discrete mathematics, their combinatorial interpretation stayed vague. We propose a novel and much simpler algorithm for the min-cost flow problem with a runtime of ~O(m^{3/2}). We consider the simplicity of the method, and the fact that the combinatorial interpretation of all its steps becomes explicit, to be our main contributions. The three algorithmic parts of our method are of independent interest and might be useful as subroutines in other approaches as well.

2 - Cut-Approximators, Approximating Undirected Max Flows, and Recursion

Richard Peng, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E18-378, Cambridge, MA, 02139, United States of America, rpeng@mit.edu

We show a closer algorithmic connection between constructing cut-approximating hierarchical tree decompositions and computing approximate maximum flows in undirected graphs. Our approach is based on invoking known algorithms for these problems recursively, while reducing problem sizes using ultra-sparsifiers. This leads to the first O(m polylog(n)) time algorithms for both problems.

3 - Near-Optimal Distributed Maximum Flow

Christoph Lenzen, MPI for Informatics, Campus E1 4, Saarbrücken, Germany, christoph.lenzen@mpi-inf.mpg.de, Mohsen Ghaffari, Fabian Kuhn, Boaz Patt-Shamir, Andreas Karrenbauer

We present a distributed (1+o(1))-approximation of max flow in undirected weighted networks with diameter D running in nearly D + sqrt(n) communication rounds of the CONGEST model. In this model, each node of the network hosts its own computing device, and in each communication round, a node can send O(log n) bits to each neighbor. This is the first improvement over the trivial quadratic bound, and the running time is optimal up to factor n^o(1). Along the way, we establish two results of independent interest: Fast distributed constructions of low average stretch spanning trees and a congestion approximator consisting of the cuts induced by O(log n) virtual trees. All our algorithms are randomized and succeed with high probability.

■ ThF13

13- Rivers

Convex Conic Optimization: Models, Properties, and Algorithms III

Cluster: Conic Programming

Invited Session

Chair: Farid Alizadeh, Professor, Rutgers University, MSIS department, 100 Rockefallar, room 5142, Piscataway, NJ, 08854, United States of America, alizadeh@rci.rutgers.edu

1 - A Branch and Bound Approach to the Minimum k-enclosing Ball Problem

Marta Cavaleiro, PhD Student, Rutgers University, RUTCOR, 100 Rockefeller, Piscataway, NJ, United States of America, marta.cavaleiro@rutgers.edu, Farid Alizadeh

The minimum k-enclosing ball problem seeks the ball with smallest radius that contains at least k of n given points. This problem is NP-hard. The minimum enclosing ball problem (requiring the ball to contain all points) can be formulated as an SOCP (in fact a QP) and solved in polynomial time, however primal and dual iterative algorithms, similar to the simplex method for LP, have also been developed. We incorporate these methods into a branch and bound search to solve the minimum k-enclosing ball problem. Additionally we use problem relaxations, using both QP and SOCP, as lower bounds in some nodes of the tree to speed up the search. Some computational results will be presented.

2 - Unifying Nesterov's Method and Nonlinear Conjugate Gradient

Stephen A. Vavasis, University of Waterloo, 200 University Avenue W., Waterloo, ON, N2L 3G1, Canada, vavasis@uwaterloo.ca, Sahar Karimi

We present a variant of nonlinear conjugate gradient method that, when applied to strongly convex functions, achieves the optimal complexity bound as Nesterov's method using a similar analysis. However, unlike Nesterov's method, the proposed method is optimal in the traditional sense of conjugate gradient when applied to convex quadratic objective functions.

3 - Solving Semi-Infinite Programs using Rational Function Approximations and Semidefinite Programming

David Papp, Assistant Professor, North Carolina State University, Department of Mathematics, 3222 SAS Hall / Campus Box 8205, Raleigh, NC, 27695, United States of America, dpapp@ncsu.edu

In the most common formulation of semi-infinite programs, the infinite constraint set is a requirement that a function parametrized by the decision variables is nonnegative over an interval. If this function is sufficiently closely approximable by a polynomial, the semi-infinite program can be reformulated as an equivalent semidefinite program. Solving this semidefinite program is challenging if the polynomials involved are of high degree. We combine rational function approximation techniques and polynomial programming to overcome the numerical difficulties that arise in the solution of these problems. Motivating applications come from statistics.

■ ThF14

14- Traders

Mechanism Design and Optimization

Cluster: Game Theory

Invited Session

Chair: Yang Cai, McGill University, 3480 University, MC 324, Montreal, QC, Canada, cai@cs.mcgill.ca

1 - Convex Optimization and Bayesian Mechanism Design I: Basic Settings and Revenue Maximization

Yang Cai, McGill University, 3480 University, MC 324, Montreal, QC, Canada, cai@cs.mcgill.ca, Constantinos Daskalakis, Seth Matthew Weinberg

In his seminal paper, Myerson [1981] provides a revenue-optimal auction for a seller who is looking to sell a single item to multiple bidders. Extending this auction to simultaneously selling multiple heterogeneous items has been one of the central problems in Mathematical Economics. By borrowing techniques from Convex Optimization, we provide such an extension that is also computationally efficient. Our auction also preserves the simple structure of Myerson's. While Myerson's auction always chooses the allocation that maximizes the virtual welfare, our allocation rule is a distribution of virtual welfare maximizers.

2 - Convex Optimization and Bayesian Mechanism Design II: Algorithms for Strategic Agents

Seth Matthew Weinberg, Princeton University, 35 Olden St, Princeton, NJ, 08540, United States of America, sethmw@cs.princeton.edu, Constantinos Daskalakis, Yang Cai

This talk will further investigate tools developed in part I to address the following question. In traditional algorithm design, no incentives come into play: the input is given and your algorithm must produce a correct output. How much harder is it to solve the same problem when the input is not given directly, but instead reported by strategic agents with interests of their own? We develop a new algorithmic framework with which to study such problems, building upon the tools developed in part I of this session. We provide a computationally efficient black-box reduction from solving any optimization problem on strategic input to solving a perturbed version of that same optimization problem when the input is directly given.

3 - Bandit in a Network

L. Elisa Celis, EPFL, Ecole Polytechnique Federale de Lausanne, Lausanne, 1015, Switzerland, elisa.celis@epfl.ch, Farnood Salehi

In many optimization settings, agents are required to make sequential decisions with limited information, and traditionally base decisions on past experience. However, agents are often also privy to the experience of others. Thus, a natural question arises: how much can one gain (individually or as a whole) from this shared knowledge? We introduce a model that captures this setting in which a network of agents play against one multi-armed bandit; each player observes her neighbor's actions and rewards in addition to her own. This naturally interpolates between the classic multi-armed bandit setting and the full-information setting from online learning. We examine this problem from both an optimization and game theoretic point of view.

■ ThF15

15- Chartiers

Synergies Between Optimization and Robust Control

Cluster: Global Optimization

Invited Session

Chair: Venkat Chandrasekaran, Caltech, 1200 E. California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, venkatc@caltech.edu

1 - Robust to Dynamics Optimization (RDO)

Amir Ali Ahmadi, Princeton University, a_a_a@princeton.edu, Oktay Gunluk

We introduce a new type of robust optimization problems that we call "robust to dynamics optimization" (RDO). The input to an RDO problem is twofold: (i) a mathematical program (e.g., an LP, SDP, IP), and (ii) a dynamical system (e.g., a linear, nonlinear, discrete, or continuous dynamics). The objective is to maximize over the set of initial conditions that forever remain feasible under the dynamics. We initiate an algorithmic study of RDO and demonstrate tractability of some important cases.

2 - Regularization for Design

Nikolai Matni, California Institute of Technology, 1200 E California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, nmatni@caltech.edu, Venkat Chandrasekaran

When designing controllers for large-scale systems, designing the controller architecture, i.e., placing sensors and actuators as well as the communication links between them, is as important as the design of the control laws themselves. We show that the architecture design task can be framed as one of seeking structured solutions to linear inverse problems. We use this observation to formulate the Regularization for Design framework, in which we augment variational formulations of controller synthesis problems with convex penalty functions that induce a desired controller architecture. We further show that the resulting convex optimization problems identify optimally structured controllers under a signal-to-noise ratio type condition.

3 - Analysis and Design of Optimization Algorithms using Robust Control

Benjamin Recht, UC Berkeley, 465 Soda Hall, MC 1776, Berkeley, CA, 94720, United States of America, brecht@berkeley.edu

I will present a method to analyze and design optimization algorithms built on the framework of Integral Quadratic Constraints (IQC) from robust control theory. IQCs provide conditions for ensuring the stability of complicated interconnected systems and can be checked via semidefinite programming. I will discuss how to adapt IQC theory to study optimization algorithms, deriving upper bounds on convergence rates for many popular optimization methods. I will close with a discussion of how these techniques can be used to search for optimization algorithms with desired performance characteristics, establishing a new methodology for algorithm design. This is joint work with Laurent Lessard and Andrew Packard.

■ ThF16

16- Sterlings 1

Risk-Averse Control of Markov Systems

Cluster: Stochastic Optimization

Invited Session

Chair: Andrzej Ruszczynski, Rutgers University, 100 Rockefeller Road, Piscataway, NJ, 08854, United States of America, rusz@business.rutgers.edu

1 - Risk-Averse Optimization of Discrete-Time Markov Systems

Andrzej Ruszczynski, Rutgers University, 100 Rockefeller Road, Piscataway, NJ, 08854, United States of America, rusz@business.rutgers.edu

First, we shall briefly review basic ideas of modeling risk in optimization problems, in particular, the use of measures of risk. Then we shall focus on modeling risk in dynamical systems and discuss the property of time consistency and the resulting interchangeability in optimal control models. Special attention will be paid to discrete-time Markov systems. We shall refine the concept of time consistency of risk measures for such systems, introducing conditional stochastic time consistency. We shall also introduce the concept of Markovian risk measures and derive their structure. This will allow us to derive a risk-averse counterpart of dynamic programming equations. Finally, we shall discuss solution methods.

2 - Dynamic Risk Measures for Finite-State Partially Observable Markov Decision Problems

Jingnan Fan, Instructor, Rutgers University, 100 Rockefeller Road, Piscataway, NJ, 08854, United States of America, jingnan.fan@rutgers.edu

We provide a theory of time-consistent dynamic risk measures for finite-state partially observable Markov decision problems. By employing our new concept of stochastic conditional time consistency, we show that such dynamic risk measures have a special structure, given by transition risk mappings as risk measures on the space of functionals on the observable state space only. Moreover, these mappings enjoy a strong law invariance property.

3 - Risk-averse Hamilton-Jacobi-Bellman Equation

Jianing Yao, PhD Student, Rutgers University, 100 Rockefeller Road, Piscataway, NJ, 08854, United States of America, jy346@scarletmail.rutgers.edu

In this paper, we study the risk-averse control problem in continuous-time setting. We make use of forward backward stochastic differential equation (FBSDE) system to evaluate fixed policy and formulate the optimal control problem. Weak formulation is established to facilitate the derivation of the risk-averse dynamic programming equation (DPE). We also prove the value function of risk-averse control problem is a viscosity solution of generalized Hamilton-Jacobian-Bellman (HJB) equation. On the other hand, verification theorem is proved when the classical solution of HJB exists.

■ ThF17

17- Sterlings 2

Optimization in Healthcare Delivery

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Rema Padman, Professor of Mgmt. Sci & Healthcare Informatics, Carnegie Mellon University, The H. John Heinz III College, Pittsburgh, PA, 15213, United States of America, rpadman@cmu.edu

1 - The Impact of Optimization on The Allocation of Livers for Organ Transplantation

Mustafa Akan, Carnegie Mellon University, akan@cmu.edu, Heidi Yeh, James Markmann, Sridhar Tayur, Zachary Leung

Patients on the waitlist for liver transplantation are prioritized according to their MELD scores, which reflects the severity of each patient's liver disease. Recent studies have shown that hepatocellular carcinoma (HCC) patients have significantly higher liver transplant rates than non-HCC patients. We recommend a family of alternative MELD score policies based on a fluid model approximation of the queueing system and an optimization model that achieves an optimal balance between efficiency and equity.

2 - Electronic Health Records For Decision Support – Meaningful Use of Complex Medical Data

Fan Yuan, Georgia Tech, Atlanta, GA, United States of America, Eva Lee

This work is joint with Grady Memorial Hospital and the Children's Healthcare of Atlanta. We focus on identifying reasons behind the recurrence of patient admissions, and designing classification models to predict potential readmissions. Large scale data analysis and results will be presented. This is critical given the Affordable Care Act is beginning to implement readmission penalties. The algorithmic approach could detect readmission triggers without human monitoring.

3 - Optimizing Order Sets for Computerized Provider Order Entry: A Mathematical Programming Approach

Daniel Gartner, Carnegie Mellon University, The H. John Heinz III College, 5000 Forbes Ave, Pittsburgh, PA, 15213-3890, United States of America, dgartner@andrew.cmu.edu, Rema Padman, Yiye Zhang

Order sets improve care delivery by allowing faster and easier physician order entry, but creating usable and relevant time-interval-clustered order sets is challenging. We formulate and solve exact and heuristic approaches to minimize physical and cognitive workloads associated with assigning order sets/a-la-carte orders to patients and selecting/deselecting appropriate orders. Dominance properties and symmetry breaking constraints boost computation speed. Using real patient data from a major pediatric hospital, we demonstrate the effectiveness of our methods.

■ ThF18

18- Sterlings 3

Large-Scale Optimization and Its Applications

Cluster: Nonlinear Programming

Invited Session

Chair: Daniel P. Robinson, 3400 N. Charles Street, Baltimore, MD, 21218, United States of America, daniel.p.robinson@gmail.com

1 - Structured Optimization with Applications in Health Care

Yueling Loh, Johns Hopkins University, 3400 North Charles Street, Baltimore, MD, 21218, United States of America, yueling.loh@gmail.com, Suchi Saria, Daniel P. Robinson

Common regularizers do not adequately account for the complex cost structures that exist in some modern applications. We present a new structured regularizer that captures these complicated cost structures and present an efficient algorithm for predictive learning that uses these regularizers. We will provide numerical results on a particular application in health care, namely the prediction of sepsis in Intensive Care Unit patients. We incorporate this regularizer into a framework that takes into account the underlying structure of patient profiles while predicting their risk of septic shock, allowing us to identify different groups of patients in order to generate tailored sets of tests and treatments.

2 - A Shifted Interior-Point Algorithm for Nonlinear Optimization

Vyacheslav Kungurtsev, Czech Technical University, Karlovo namesti 9, Prague, Czech Republic, slavakung2@gmail.com, Daniel P. Robinson, Philip E. Gill

Interior methods provide an effective approach for the treatment of inequality constraints in nonlinearly constrained optimization. A new primal-dual interior method is proposed that has favorable global convergence properties, yet, under suitable assumptions, is equivalent to the conventional path-following interior method in the neighborhood of a solution. The method may be combined with a primal-dual shifted penalty function for the treatment of equality constraints to provide a method for general optimization problems with a mixture of equality and inequality constraints.

■ ThF19

19- Ft. Pitt

Game Theoretic Aspects of Social Choice

Cluster: Game Theory

Invited Session

Chair: Lirong Xia, RPI, 110 8th Street, Computer Science Department, Troy, NY, 12180, United States of America, xial@cs.rpi.edu

1 - An Algorithmic Framework for Strategic Fair Division

Ariel Procaccia, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, United States of America, arielpro@cs.cmu.edu, David Kurokawa, Ioannis Caragiannis, Simina Branzei

Classic cake cutting protocols are susceptible to manipulation. Do their strategic outcomes still guarantee fairness? To address this question we adopt a novel algorithmic approach, proposing a concrete computational model and reasoning about the game-theoretic properties of algorithms that operate in this model. Specifically, we show that each protocol in the class of generalized cut and choose (GCC) protocols is guaranteed to have approximate subgame perfect Nash equilibria, or even exact equilibria if the protocol's tie-breaking rule is flexible. We further observe that the (approximate) equilibria of proportional protocols must be (approximately) proportional, thereby answering the above question in the positive.

2 - A Local-Dominance Theory of Voting Equilibria

Reshef Meir, reshef24@gmail.com

We suggest a new model for strategic voting based on local dominance, where voters consider a set of possible outcomes without assigning probabilities to them. We prove that local dominance-based dynamics quickly converge to an equilibrium (and in particular that an equilibrium exists). Using extensive simulations of strategic voting, we show that emerging equilibria replicate known patterns of human voting behavior such as Duverger's law, and usually yield a better winner than truthful Plurality.

3 - Price of Anarchy, Price of Stability, and the Condorcet Jury Theorem

Lirong Xia, RPI, 110 8th Street, Computer Science Department, Troy, NY, 12180, United States of America, xial@cs.rpi.edu

We initiate the study of price of anarchy (PoA) and price of stability (PoS) for social choice mechanisms in Bayesian games motivated by the Condorcet Jury Theorem, where strategic agents receive noisy signals about the ground truth. The social welfare and agents' utility are defined by the probability for the mechanism to reveal the ground truth. We characterize the PoA and PoS of the common interest social choice game for two types of mechanisms: (1) The mode mechanism, which chooses an alternative that receives most votes uniformly at random. (2) All mechanisms that satisfy three axiomatic properties: anonymity, neutrality, and strategy-proofness for all distance-based models.

ThF20

20- Smithfield

Coordinate Descent Methods for Sparse Optimization Problems II

Cluster: Nonsmooth Optimization

Invited Session

Chair: Xin Liu, Associate Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, ICMSEC510, 55, Zhong Guan Cun East Road, Beijing, China, liuxin@lsec.cc.ac.cn

1 - An Alternating Minimization Method for A Class of Rank Constrained Problems

Yuan Shen, Assistant professor, Nanjing University of Finance & Economics, School of Applied Mathematics, No 3, Wenyuan Road, Qixia District, Nanjing, 210023, China, ocsiban@126.com, Yin Zhang, Zaiwen Wen, Xin Liu

In this paper, we focus on solving a class of rank constrained optimizations which arises from many applications in the fields of information theory, statistics, engineering, etc. However, the inherent nonconvexity of this type of optimization makes it difficult to handle. Traditional approach uses a nuclear norm term to replace the rank constraints. The yielded model is convex, and can be solved by a bunch of existing algorithms. However, these algorithms need to compute Singular Value Decomposition which is expensive. We retains the rank constraints in the optimization model, and propose an alternating minimization method. The yielded algorithm shows satisfactory speed performance, and its theoretical property is also analyzed.

2 - On The Global Optimality For Linear Constrained Rank Minimization Problems

Hong Wang, Mr., The Hong Kong Polytechnic University, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, hong.wang@connect.polyu.hk, Xiaojun Chen, Ya-xiang Yuan, Xin Liu

In this paper, we first focus on exploring the theoretical properties of the factorization model for rank minimization problems with linear constraints. And then based on such properties, we propose an algorithm framework which returns the global solution of the linear constrained rank minimization problem. We also show the relationship between the factorization model and the corresponding rank constrained linear least squares model. Finally, we put forward a conjecture that the reduction between the global minima of problems with consecutive ranks is monotonically decreasing with the increasing of the rank.

3 - A Parallel Line Search Subspace Correction Method for Composite Convex Optimization

Qian Dong, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, No.55, ZhongGuanCun DongLu, P.O.Box 2719, Beijing, 100190, China, dongqian@lsec.cc.ac.cn, Zaiwen Wen, Ya-xiang Yuan, Xin Liu

We investigate a parallel subspace correction framework for composite convex optimization based domain decomposition method. At each iteration, the algorithms solve subproblems on subspaces simultaneously to construct a search direction and take the Armijo line search to find a new point. They are called PSCLN and PSCLO, respectively, depending on whether there are overlapping variables. Their convergence is established under mild assumptions. We compare them with state-of-the-art algorithms for solving LASSO problems, which shows that PSCLN and PSCLO can run fast and return solutions no worse than those from the others. It is also observed that the overlapping scheme is helpful for the structured-data problem.

ThF21

21-Birmingham

Software Tools for Optimization

Cluster: Implementations and Software

Invited Session

Chair: Matthew Saltzman, Clemson University, Mathematical Sciences Department, Martin Hall, Box 340975, Clemson, SC, 29634, United States of America, mjs@clemson.edu

1 - Benchmarks of Distributed Solvers for Mixed-Integer Linear Programs on a High Performance Computer

Thorsten Ederer, TU Darmstadt, Magdalenenstr. 4, Darmstadt, 64289, Germany, ederer@mathematik.tu-darmstadt.de, Thomas Opfer

MILP algorithms usually run on a single compute node and utilize threads in a shared-memory context. Recent versions of leading solvers introduced a feature to distribute the Branch-and-Bound tree over multiple machines. We compare these parallel capabilities using the Lichtenberg High Performance Computer of TU Darmstadt. Promising initial tests with the MIPLIB benchmark test set have been conducted on up to 32 Haswell nodes with up to 24 cores and a FDR-14 Infiniband interconnect.

2 - COIN-OR at 15: Open Source Tools for Operations Research

Matthew Saltzman, Clemson University, Mathematical Sciences Department, Martin Hall, Box 340975, Clemson, SC, 29634, United States of America, mjs@clemson.edu, Ted Ralphs

The COIN-OR initiative was inaugurated at ISMP 2000 in Atlanta. We report on the progress and impact of COIN-OR over the past fifteen years, the state of the initiative today, currently available tools, and how new developers and users can get involved.

3 - Revisiting Expression Representations and Automatic Differentiation for Nonlinear AMPL Models

David Gay, AMPL Optimization, Inc., 900 Sierra Place SE, Albuquerque, NM, 87108-3379, United States of America, dmg@ampl.com

Currently the AMPL/Solver interface library uses "executable" expression graphs to represent nonlinear objectives and constraint bodies; each node points to a little function implementing the operation represented by the node. Each node also stores partial derivatives for use in computing derivatives. This makes the graphs nonreentrant. To permit several threads to evaluate the same expression at different points without having separate copies of the expression graphs, such details as variable values and partial derivatives must be stored in thread-specific arrays. We describe and compare some possible alternative representations for use in function and gradient evaluations.

ThF22

22- Heinz

Inventory and Supply Chain Applications

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Eneko Malatsetxebarria, Research Engineer, ArcelorMittal, Global R&D Asturias P.O. Box 90, Aviles, 33400, Spain, eneko.malatsetxebarria@arcelormittal.com

1 - Lifecycle Pricing and Inventory Optimization in an Omni-channel Retail Environment

Pavithra Harsha, IBM Research, 1101 Kitchawan Road, Room 34-225, Yorktown Heights, NY, 10598, United States of America, pharsha@us.ibm.com, Markus Ettl, Shiva Subramanian, Joline Uichanco

Lifecycle pricing is traditionally done for a single sales channel where inventory is exogenous. However, this ignores customers channel-switching due to differences in prices in different channels and cross-channel fulfillments such as buy online pickup in store and ship-from-store where inventory is not exclusive to one channel. We develop an optimization model for joint price and inventory management in an omni-channel retail environment that accounts for the current drawbacks and present results on real data.

2 - A Particle Swarm Optimization Approach to the Part-Supplying Problem at Assembly Lines

Dalila Fontes, Professor, Universidade do Porto, Faculdade de Economia and LIAAD - INESC, Universidade do Porto, Porto, 4200 - 464, Portugal, fontes@fep.up.pt, Masood Fathi

The Assembly Line Part-Supplying Problem concerns the delivery of parts to the workstations in a mixed-model assembly line. Here, we consider the problem of delivering the parts from a decentralized logistics area, through round trips. In order to provide the workstations with the needed parts, one has to decide which parts and respective amounts to load on each tour, while minimizing both the number of tours and the part inventories at the workstations. Limits are imposed on tour capacity and on storage capacity at the workstations. We propose a Particle Swarm Optimization algorithm to address this problem with a tour time additional constraint. The results obtained have shown the method to be efficient and effective.

3 - Robust Optimization of a Raw Materials Distribution Problem through Pessimization

Eneko Malatsetxebarria, Research Engineer, ArcelorMittal, Global R&D Asturias P.O. Box 90, Aviles, 33400, Spain, eneko.malatsetxebarria@arcelormittal.com, Diego Diaz, Pablo Valledor, Tatiana Manso

The robust optimization of large-scale logistics problems with uncertainties in transport durations and many integer variables can be difficult to tackle. In order to circumvent this, we show a real case application of a worst-case analysis by using a pessimizing oracle. This is done for an inventory control problem with fixed demand but uncertain bulk arrivals of multiple products with linked consumption, where the pessimizing oracle considers inventory levels and stock rupture events.

■ ThF23

23- Allegheny

Discrete Convex Analysis II

Cluster: Combinatorial Optimization

Invited Session

Chair: Kazuo Murota, University of Tokyo, Bunkyo-ku, Tokyo, Japan, murota@mist.i.u-tokyo.ac.jp

1 - L-natural-convexity And Its Applications In Operations Models

Xin Chen, University of Illinois, UIUC, xinchen@illinois.edu

L-Natural-convexity, an important concept from discrete convex analysis, provides a powerful tool to derive structural results of optimal policies in a variety of operations models. In this talk, I will illustrate how it can be used, by developing new preservation properties, to establish monotone comparative statics in several challenging applications including perishable inventory models, dual sourcing models with uncertain supply capacities, and joint inventory and transshipment control models.

2 - Exact Bounds For Steepest Descent Algorithms of L-convex Function Minimization

Akiyoshi Shioura, Tokyo Institute of Technology, Oh-okayama, Meguro-ku, Tokyo, Japan, shioura.a.aa@m.titech.ac.jp, Kazuo Murota

We analyze minimization algorithms for L-convex functions in discrete convex analysis, and establish exact bounds for the number of iterations required by the steepest descent algorithm and its variants. We also mention the implication of our results to the research areas such as discrete optimization, computer vision, and iterative auction.

3 - Multi-Unit Trading Networks with Discrete Concave Utility Functions

Yosuke Sekiguchi, Keio University, Hiyoshi, Kohoku-ku, Yokohama, 223-8522, Japan, sekiguchi@math.keio.ac.jp, Akihisa Tamura, Yoshiko Ikebe, Akiyoshi Shioura

We propose a model of trading networks in which multiple units of contracts are allowed. We assume that valuation functions of all agents are twisted M#-concave functions, which play a central role in our model. We show that competitive equilibria always exist and the set of competitive equilibrium price vectors forms a lattice in this setting. Furthermore, we consider the connection between competitive equilibria and stable outcomes in the model.

■ ThF24

24- Benedum

Algorithms for Problems with Combinatorial Structure

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Miguel Anjos, Professor and Canada Research Chair, Polytechnique Montreal, C.P. 6079, Succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, miguel-f.anjos@polymtl.ca

1 - A New Exact Solution Approach for the Quadratic Matching Problem

Lena Hupp, FAU Erlangen-Nuernberg, Cauerstrafle 11, Erlangen, Germany, Lena.Hupp@math.uni-erlangen.de, Laura Klein, Frauke Liers

The quadratic matching problem (QMP) generalizes the quadratic assignment problem. The QMP asks for a matching in a graph that optimizes a quadratic objective in the edge variables. In our approach the linearized IP-formulation is strengthened by facets of the corresponding problem where the objective contains only one quadratic term. We present methods to generalize them in order to design cutting planes for QMP. We develop an exact branch-and-cut approach and report computational results.

2 - Lift-and-Convexification Approach for Quadratic Programming with Semi-Continuous Variables

Baiyi Wu, The Chinese University of Hong Kong, Room 609, William M. W. Mong Engineering, Building, CUHK, Hong Kong, Hong Kong, Hong Kong - PRC, baiyiwu@gmail.com, Duan Li, Xiaojin Zheng

We propose a lift-and-convexification approach to derive an equivalent linearly constrained mixed-integer reformulation for quadratic programming problems with semi-continuous variables. It improves the performance of branch-and-bound algorithms by providing the same tightness at the root node as the state-of-the-art perspective reformulation and much faster child-node processing time. Furthermore, quadratic convex reformulation technique can be applied to our new reformulation to obtain an even tighter bound. Promising computational results verify the benefits of our new reformulations.

3 - Polyhedral Study of Linearizations of Polynomial Matroid Optimisation Problems

Anja Fischer, TU Dortmund, Department of Mathematics, Vogelpothsweg 87, Dortmund, Germany, anja.fischer@mathematik.tu-dortmund.de, Frank Fischer, S. Thomas McCormick

We consider polynomial matroid optimization problems with some non-linear monomial in the objective function. The monomials are linearized and we study the corresponding polytopes. Extending results of Edmonds we present complete descriptions for the linearized polytopes given a set of nested monomials and given a set of monomials fulfilling certain up- and downward completeness conditions. Indeed, apart from the standard linearization in these cases one needs appropriately strengthened rank inequalities. The separation problems of these constraints reduce to submodular function minimization problems. In the case of exactly one non-linear monomial we even completely characterize the facetial structure of the associated polytope.

■ ThF25

25- Board Room

Stochastic Aspects of Energy Management I

Cluster: Optimization in Energy Systems

Invited Session

Chair: Wim van Ackooij, EDF R&D, 1 Avenue du Général de Gaulle, Clamart, 92141, France, wim.van.ackooij@gmail.com

1 - Modeling Demand Response Resources in Large-Scale Unit Commitment Models

Elaine Hale, Senior Engineer, National Renewable Energy Laboratory, 15013 Denver West Parkway, MS RSF300, Golden, CO, 80401, United States of America, elaine.hale@nrel.gov

Integrating large proportions of renewable, variable generation into power systems requires increased system flexibility. One possible source of flexibility is demand response, in which a load's power draw is adjusted or on standby to help achieve power system balance and reliability. Mathematically, demand response is not yet integrated into standard grid modeling tools. This talk will describe how such resources can be modeled, both from an optimization problem formulation perspective, and within existing tools. Computational results and performance are presented and discussed.

2 - Robust Control Command Strategies in a Contract-Based Collaboration Framework

Rosa de Figueiredo, LIA, UAPV, Agroparc, Avignon, France, rosamaria.figueiredo@gmail.com, Antoine Jouglet, David Savourey

We consider two entities that are both producer and consumer of a same kind of energy resource and have to collaborate to balance their consumption and production over a given time horizon. We tackle the problem from a real time viewpoint by modeling the decisions that must be taken every delta units of time. Moreover, we assume that the production is uncertain. Our resulting robust optimization model must determine an optimal (according to the cost) contract subscription from the client to the partner in such a way that there exists a robust real time command strategy which satisfies consumer demands of the client subsystems over the time horizon and in such a way that each commitment taken by the client with the partner is honored.

3 - A Dynamic Programming Approach for a Class of Robust Optimization Problems

Michael Poss, LIRMM, 161 rue Ada, Montpellier, 34392, France, michael.poss@lirmm.fr, Marcio Costa Santos, Agostinho Agra, Dritan Nace

Common approaches to solve a robust optimization problem decompose the problem into a master problem (MP) and adversarial separation problems (APs). MP contains the original robust constraints, however written only for finite numbers of scenarios. Additional scenarios are generated on the fly by solving the APs. We consider in this work the budgeted uncertainty polytope and propose new dynamic programming algorithms to solve the APs that are based on the maximum number of deviations allowed and on the size of the deviations. Our algorithms can be applied to robust constraints that occur in various applications such as lot-sizing and TSP with time-windows, among many others. We assess numerically our approach on a lot-sizing problem.

■ ThF26

26- Forbes Room

Stochastic Convex Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Umit Tursun, Postdoctoral Research Associate, University of Illinois at Urbana-Champaign, 117 Transportation Bldg., 104 S. Mathews, Room 214, Urbana, IL, 61801, United States of America, utursu2@illinois.edu

1 - Optimal Dividend Payment under Time of Ruin Constraint: Exponential Case

Camilo Hernandez, Universidad de los Andes, Cra 1 N∫ 18A- 12 Dep. de Matematicas, Bogota, Colombia, mc.hernandez131@uniandes.edu.co, Mauricio Junca

We consider the classical optimal dividend payments problem under the Cram\'er-Lundberg model with exponential claim sizes subject to a constraint on the time of ruin P1. We use the Lagrangian dual function which leads to an auxiliary problem P2. For this problem, given a multiplier Λ, we prove the uniqueness of the optimal barrier strategy and we also obtain its value function. Finally, we prove that the optimal value function of P1 is obtained as the point-wise infimum over Λ of all value functions of problems P2. We also present a series of numerical examples.

2 - Stochastic Online Optimization with Noisy First Order Oracle

Daniil Merkulov, MIPT, Bulvar Svobodi, 3-19, Sergiyev Posad, Russia, bratishka.mipt@gmail.com

We consider the stochastic online optimization problem. We assume that only noisy stochastic gradients can be obtained from the oracle. We use two assumptions about noise, which goes back to the Juditski-Nemirovski'11 and to the Devolder-Gellineur-Nesterov'11. We demonstrate how to generalize this concept in online context. Additionally, we investigate corresponding theorem about mirror descent convergence in stochastic online context with inexact oracle. All estimations are unimprovable up to a logarithmic factor. We also consider applications to the contextual bandits and SLT.

3 - Stochastic Convex Minimization: Random Projection Algorithms in the Presence of Noise

Umit Tursun, Postdoctoral Research Associate, University of Illinois at Urbana-Champaign, 117 Transportation Bldg., 104 S. Mathews, Room 214, Urbana, IL, 61801, United States of America, utursu2@illinois.edu

The focus of this work is stochastic convex minimization problems with uncertain objectives over arbitrary family of convex sets. Constraint sets are not known in advance yet revealed one by one or chosen randomly at each algorithm iteration. We consider a two step random projection algorithm. First step is a stochastic gradient projection. Gradient for this step carries stochastic error with centered and bounded deterministic variance. The feasibility violation of the intermittent point with respect to the revealed/chosen constraint set is mitigated at second step of algorithm The proposed algorithm can handle finitely many number of convex constraint sets as well as infinite number of them by proceeding through a random subset of them.

■ ThF27

27- Duquesne Room

Stable Matching Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Rakesh Vohra, University of Pennsylvania, 3718 Locust Walk, Philadelphia, PA, United States of America, rvohra@seas.upenn.edu

1 - On Weighted Kernels of Two Posets

Tamas Fleiner, Budapest University of Technology and Economics, Dept of Comp Sci and Information Theory, Magyar Tudòsok Köerútja 2., Budapest, H-1117, Hungary, fleiner@cs.elte.hu, Zsuzsanna Jankó

A recent result of Aharoni Berger and Gorelik is a weighted generalization of the well-known theorem of Sands Sauer and Woodrow on monochromatic paths. The authors prove the existence of a so called weighted kernel for any pair of weighted posets on the same ground set. In this work, we point out that this result is closely related to the stable marriage theorem of Gale and Shapley, and we generalize Blair's theorem by showing that weighted kernels form a lattice under a certain natural order. To illustrate the applicability of our approach, we prove further weighted generalizations of the Sands Sauer Woodrow result.

2 - Matching with Externalities

Bumin Yenmez, Carnegie-Mellon University, Tepper School of Business, 5000 Forbes Av., Pittsburgh, PA, 15217, United States of America, byenmez@cmu.edu, Kyle Woodward

We incorporate externalities into the stable matching theory of two-sided markets. To this end, we establish the existence of stable matchings provided that externalities are positive and agents' preferences satisfy substitutability, and we show that the standard insights of matching theory—-e.g. the existence of side optimal stable matchings and the rural hospital theorem—-remain valid despite the presence of externalities. Furthermore, we establish novel comparative statics on externalities.

3 - Near Feasible Stable Matchings with Complementarities

Thanh Nguyen, Krannert School of Management, Purdue University, West Lafayette, United States of America, nguye161@purdue.edu, Rakesh Vohra

The National Resident Matching program strives for a stable matching of medical Students to teaching hospitals. With the presence of couples, stable matchings need not exist. For any Student preferences, we show that each instance of a stable matching problem has a `nearby' instance with a stable matching. The nearby instance is obtained by perturbing the capacities of the hospitals. Our approach is general and applies to other type of complementarities, as well as matchings with side constraints and contracts.

■ ThF28

28- Liberty Room

Complex Networks Analysis and Design under Uncertainty

Cluster: Telecommunications and Networks

Invited Session

Chair: Alexander Veremyev, University of Florida, 303 Weil Hall, Gainesville, FL, United States of America, averemyev@ufl.edu

1 - Finding Groups with the Largest Betweenness Centrality

Oleg A. Prokopyev, University of Pittsburgh, 3700 O'Hara Street, Benedum Hall 1048, Pittsburgh, PA, 15261-3048, United States of America, prokopyev@engr.pitt.edu, Alexander Veremyev, Eduardo Pasiliao

The betweeness centrality metric captures significance of a given node to the network structure under the assumption that all nodes exchange information along shortest paths. The concept of the betweenness centrality can be naturally generalized to a group of nodes and/or edges. In this talk we consider solution approaches (based on integer programming techniques) for finding a cluster of graph elements (possibly, with some conditions on inter-relationships within the cluster) with the largest betweenness centrality (or, one of its variations). We conduct extensive computational experiments with real-life and randomly generated instances that reveal interesting insights and demonstrate the advantages and limitations of our approaches.

2 - Nonzero-Sum Nonlinear Network Path Interdiction

Noam Goldberg, Bar-Ilan University, Max ve-Anna Webb St., Ramat Gan, 5290002, Israel, noam.goldberg@gmail.com

A novel nonzero-sum game is presented for a variant of a classical network interdiction problem. In this model an interdictor (e.g. an enforcement agent) decides how much of an inspection resource to spend along each arc in the network in order to capture the evader (e.g. a smuggler). The evader selects a probability distribution on paths from source nodes to destinations. The evasion probabilities nonlinearly decrease in the inspection resources spent. We show that under reasonable assumptions, with respect to the evasion probability functions, Nash equilibria of this game can be determined (approximately) in polynomial time. Stronger results are also presented in the special case of exponential functions.

3 - Achieving the Spatial Connectivity of Parcels in the Dynamic Reserve Network Design Problem

Nahid Jafari, University of Georgia, nahid.jafari@uga.edu, Clinton Moore

The conservation (reserve) network design problem is challenging to solve because of the spatial and temporal nature of the problem, uncertainties in the decision process, and possibly alternative conservation actions for any given land parcel. We propose a Mixed Integer Programming model that guarantees the fully connected budget-constrained selection of sites for conservation of species. It maximizes conservation measure at the end of the planning horizon under stochastic costs and uncertain land use change.

■ ThF29

29- Commonwealth 1

Computational Integer Programming

Cluster: Implementations and Software

Invited Session

Chair: Daniel Steffy, steffy@oakland.edu

1 - Facets for the Master Knapsack Polytope

Daniel Steffy, steffy@oakland.edu, Sangho Shim, Sunil Chopra

Through the use of shooting experiments and worst case analysis Shim, Cao and Chopra have demonstrated the strength of 1/k-facets for the master knapsack polytope. The 1/k-facets are facets whose coefficients are multiples of 1/k, and they are particularly strong for smaller values of k. For the general integer knapsack problem, or knapsack sub-problem, with l variables, the number of 1/k-facets is O(l^(k/2)). We describe algorithms for separating 1/k-facets for the general integer knapsack problem for some small values of k. Additionally, we draw new insights from additional shooting experiments, including the observation that facets arising from Gomory's homomorphic lifting are strong.

2 - An Extended Formulation of the Convex Recoloring Problem on a Tree

Sangho Shim, Kellogg School of Management, 2001 Sheridan Road Suite 548, Kellogg School of Management, Evanston, IL, 60208, United States of America, shim@kellogg.northwestern.edu, Minseok Ryu, Kangbok Lee, Sunil Chopra

We introduce a strong extended formulation of the convex recoloring problem on a tree, which has an application in analyzing a phylogenetic tree. The extended formulation has only polynomial number of constraints, but dominates the conventional formulation and the exponentially many previously known valid inequalities. We show that the valid inequalities can be derived from the extended formulation. The extended formulation solves the problems on the phylogenetic trees given by treeBASE.org at the root node of the branch-and-bound tree without branching. The solution time using the extended formulation is much faster than any other known algorithm.

3 - Some More Ways to use Dual Information in MILP

Imre Polik, SAS Institute, 500 SAS Campus Dr, Cary, NC, 27513, United States of America, imre@polik.net, Philipp Christophel, Menal Güzelsoy, Amar Narisetty, Yan Xu

Building on the concept of a dual information cache we talked about earlier, we are presenting some more ways to use this information.

■ ThF30

30- Commonwealth 2

Approximation and Online Algorithms XII

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Kunal Talwar, Google, 1600 Amphitheater Parkway, Mountain View, CA, 94043, United States of America, kunal@kunaltalwar.org

1 - Constant Factor Approximation for Balanced Cut in the PIE Model

Konstantin Makarychev, Researcher, Microsoft Research, One Microsoft Drive, Redmond, WA, 98052, United States of America, kmakaryc@cs.princeton.edu, Yury Makarychev, Aravindan Vijayaraghavan

We propose and study a new semi-random model for Balanced Cut, a planted model with permutation-invariant random edges (PIE). Our model is much more general than planted models considered previously. Consider a set of vertices V partitioned into two clusters L and R of equal size. Let G be an arbitrary graph on V with no edges between L and R. Let E_Random be a set of edges sampled from an arbitrary permutation-invariant distribution (a distribution that is invariant under permutation of vertices in L and in R). We say that G+E_Random is a graph from the PIE model. We present a constant factor approximation algorithm for the Balanced Cut problem in the PIE model for graphs with the size of the cut between L and R at least n poly-log n.

2 - Approximating Hereditary Discrepancy via Small Width Ellipsoids

Kunal Talwar, Google, 1600 Amphitheater Parkway, Mountain View, CA, 94043, United States of America, kunal@kunaltalwar.org, Aleksandar Nikolov

The Discrepancy of a hypergraph is the minimum attainable value, over two-colorings of its vertices, of the maximum absolute imbalance of any hyperedge. The Hereditary Discrepancy (HerDisc) of a hypergraph, defined as the maximum discrepancy of a restriction of the hypergraph to a subset of its vertices, is a measure of its complexity. Lovasz, Spencer and Vesztergombi (1986) related the natural extension of this quantity to matrices, to rounding algorithms for linear programs. In this work, we give a O(log^1.5 n)-approximation algorithm for HerDisc. We show that a factorization norm γ_2 studied in functional analysis, and can be computed as an optimum of a natural convex program gives a good approximation to HerDisc.

3 - An Experimental Analysis of Karp-Karmarkar One-Dimensional Bin Packing Algorithm

Otavio Silva,Centro de Informatica, Av. Jornalista Anibal Fernandes, s/n - C, Recife, Brazil, olas@cin.ufpe.br, David Johnson, Ricardo Silva

In this work, we present an experimental analysis and validation of the theoretical results about the three polynomial-time approximation algorithms for the one-dimensional bin-packing problem, designed by Karp and Karmarkar in the work entitled "An efficient aproximation scheme for the one-dimensional bin-packing problem", published in proceedings of the 23rd Annual Symposium on Foundations of Computer Science sponsored by IEEE Computer Society in 1982, pages 312-320.

Friday, 9:00am - 9:50am

■ FA01

01- Grand 1

Laplacian Matrices of Graphs: Algorithms and Applications

Cluster: Plenary

Invited Session

Chair: David Williamson, Professor, Cornell University, 236 Rhodes Hall, Ithaca, NY, 14850, United States of America, dpw@cs.cornell.edu

1 - Laplacian Matrices of Graphs: Algorithms and Applications

Daniel Spielman, Yale University, New Haven, CT, United States of America, spielman@cs.yale.edu

The problem of solving systems of linear equations in the Laplacian matrices of graphs arises in many fields including Optimization, Machine Learning, Computer Vision, and of course Computational Science. We will explain what these matrices are and why they arise in so many applications. We then will survey recently developed algorithms that allow us to solve such systems of

linear equations in nearly-linear time. The main tools used in these algorithms are sparse approximations of graphs and approximations of graphs by low-stretch spanning trees. The ability to quickly solve such systems of equations has led to the asymptotically fastest algorithms for computing maximum flows and minimum cost flows. The techniques used in the Laplacian equation solvers have been used to design the fastest algorithms for approximating maximum flows. We will provide an introduction to these recent developments.

Friday, 10:20am - 11:50am

FB01

01- Grand 1

Complementarity/Variational Inequality VII

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Stephan Dempe, TU Bergakademie Freiberg, Freiberg, 09596, Germany, dempe@tu-freiberg.de

1 - Using Mathematical Programming with Equilibrium Constraints for Parameter Identification in Contact

Ying Lu, PhD, Rensselaer Polytechnic Institute, 2408 21st Street, Apt. 6, Troy, NY, 12180, United States of America, rosebudflyaway@gmail.com, Jeff Trinkle

A common model of contact dynamics used in robotics takes the form of complementarity problem. When comparing the behaviors of multibody contact of dynamics simulation, with real physical experiment data, in order to verify the reliability and robustness of simulation methods, we have to identify the unmeasurable system parameters such as frictional coefficients. We introduce an optimization approach to solve this problem. The objective function is the sum of squared errors at each time step and the constraints are a set of complementarity conditions defining the simulation model. The result is a challenging MPEC problem. We study the performance of several derivative-free optimization methods in solving this problem.

2 - Solution Algorithm for Bilevel Optimization Problems

Stephan Dempe, TU Bergakademie Freiberg, Freiberg, 09596, Germany, dempe@tu-freiberg.de

Bilevel optimization problems are problems of minimizing an objective function subject to the graph of a second parametric optimization problem. This problem is transformed using the optimal value function of the lower level problem. The reason for this is explained. To solve it, the optimal value function is approximated from above. Realization of the resulting algorithm is explained if the lower level problem is fully convex. Convergence to a global respectively local solution is shown.

3 - Equivalent Convex Problems in the Pre-Dual Space

Michael Rotkowitz, University of Maryland, Dept. of ECE, A.V. Williams Bldg., The University of Maryland, College Park, MD, 20742, United States of America, mcrotk@umd.edu

Given a constrained convex optimization problem, we discuss the formulation and solution of equivalent problems in the pre-dual space. This is intended for problems where the dual of the constraint space cannot be easily classified or is not well-understood, but the pre-dual space can be classified. Our main motivation is constrained control problems in the Hardy space H-infinity; the space of functions of bounded variation is another space of this nature.

FB02

02- Grand 2

Recent Advances in Copositive Programming

Cluster: Conic Programming

Invited Session

Chair: Roland Hildebrand, Weierstrass Institute, Mohrenstrasse 39, Berlin, 10117, Germany, roland.hildebrand@wias-berlin.de

1 - Scaling Relationship between the Copositive Cone and Parrilo's First Level Approximation

Peter Dickinson, University of Twente, P.O. Box 217, Enschede, 7500 AE, Netherlands, p.j.c.dickinson@utwente.nl, Mirjam Dür, Luuk Gijben, Roland Hildebrand

Winner of the 2013 OPTL Best Paper Award. In this talk we consider Parillo's inner approximations of the copositive cone. For orders greater than four we show that, in contrast to the copositive cone, Parillo's approximations are not invariant under scalings, and thus are not equal to the copositive cone. This opens up scalings as a new line of research for considering how to improve inner approximations of the copositive cone.

2 - On Completely Positive Modeling of Quadratic Problems

Duy-Van Nguyen, Trier University, Department of Mathematics, Trier, 54286, Germany, nguyen@uni-trier.de, Mirjam Dür

Copositive programming deals with linear optimization problems over the copositive cone and its dual, the completely positive cone. The motivation to study this type of problem is that many nonlinear quadratic problems (even with binary constraints) can be cast in this framework. In order to have strong duality in conic optimization, strict feasibility of the problems is required. Strict feasibility is also advantagous in numerical solution approaches, for example when inner approximations of the copositive cone are used. We show that not all of the known completely positive formulations of quadratic and combinatorial problems are strictly feasible and discuss conditions which ensure this property.

3 - Representations of the Interior of the Completely Positive Cone

Patrick Groetzner, University of Trier, Department of Mathematics, Trier, 54286, Germany, groetzner@uni-trier.de, Mirjam Dür

Many combinatorial and nonlinear problems can be reformulated as convex problems using the copositive and the completely positive cone. Therefore it is of interest, whether a matrix is in the interior of one of these cones. There are some characterizations for the interior of the completely positive cone, which just provide sufficient but not necessary conditions. The main goal of this talk is to extend these known characterizations using certain orthogonal transformations.

FB03

03- Grand 3

Algorithms for Combinatorial Optimization Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Asaf Levin, The Technion, Faculty of IE&M, The Technion, The Technion City, Haifa, Israel, levinas@ie.technion.ac.il

1 - Models for the k-Metric Dimension

Leah Epstein, University of Haifa, Mount Carmel, Haifa, Israel, lea@math.haifa.ac.il, Ron Adar

For an undirected graph, a vertex x separates vertices u and v\neq u, if their distances to x are distinct. For a parameter k, a subset of vertices L is a feasible landmark set, if for every two vertices, there are at least k vertices in L, each separating them. We study a generalization of the classic problem (where k=1) for k>1, and analyze two models. In AP, k separations are needed for every pair of distinct vertices of V, while in NL, such separations are needed only for pairs of vertices in V\L. We focus on the weighted version, where the goal it to find a minimum cost solution, and design algorithms for several graph classes. We demonstrate the differences between the two new models, and between the cases k=1 and k>1.

2 - A Polynomial-Time Approximation Scheme for the Airplane Refueling Problem

Danny Segev, University of Haifa, Department of Statistics, Haifa, 31905, Israel, segev.danny@gmail.com, Iftah Gamzu

We propose a polynomial-time approximation scheme for the airplane refueling problem, which was introduced by the physicists George Gamow and Marvin Stern in their classical book "Puzzle-Math" (1958). Sticking to the original story behind this problem, suppose we have to deliver a bomb in some distant point of the globe, the distance being much greater than the range of any individual airplane at our disposal. Thus, the only feasible option to carry out this mission is to better utilize our fleet via mid-air refueling. Starting with several airplanes that can refuel one another, and gradually drop out of the flight until the single plane carrying the bomb reaches the target, how would you plan the refueling policy?

3 - Improved Approximation Algorithms for Discounted Reward TSP

Asaf Levin, The Technion, Faculty of IE&M, The Technion, The Technion City, Haifa, Israel, levinas@ie.technion.ac.il, Boaz Farbstein

The Discounted Reward TSP is defined as follows. The input is a graph G=(V,E) where each node v has an initial prize pi(v) and this prize deteriorates exponentially. Therefore, the prize collected from node v is pi(v) times lambda^t, where lambda is the deterioration rate and t is the total distance until the first time v was visited. The objective is to find a path that maximizes the total prize collected from the nodes of G. We present two different algorithms for Discounted Reward TSP, each improving the previously best known approximation ratio of 0.1481-delta shown by Blum et al. (SICOMP'07). Our better algorithm is a (0.1929-delta)-approximation algorithm.

■ FB04

04- Grand 4

Semidefinite Programming for Polynomial and Tensor Optimization

Cluster: Conic Programming

Invited Session

Chair: João Gouveia, University of Coimbra, Apartado 3008 EC Santa Cruz, Coimbra, 3001-501, Portugal, jgouveia@mat.uc.pt

Co-Chair: Hamza Fawzi, Massachusetts Institute of Technology, Cambridge MA 02139, hfawzi@mit.edu

Co-Chair: James Saunderson, Massachusetts Institute of Technology, 77 Massachusetts Ave, 32-D572, Cambridge, MA, 02139, United States of America, jamess@mit.edu

1 - Sparse Sum-of-Squares Certificates on Finite Abelian Groups

James Saunderson, Massachusetts Institute of Technology, 77 Massachusetts Ave, 32-D572, Cambridge, MA, 02139, United States of America, jamess@mit.edu, Hamza Fawzi, Pablo Parrilo

We consider functions on finite abelian groups that are non-negative and also sparse in the Fourier basis. We investigate when such functions are sums of squares of functions with a small common Fourier support. We give a combinatorial condition for this based on finding chordal covers (with additional symmetry properties) of a graph that encodes the group and sparsity pattern of interest. These techniques allow us to resolve a conjecture of Laurent about non-negative quadratic functions on the hypercube, and to prove that a certain family of trigonometric cyclic polytopes (indexed by dimension) have significantly smaller SDP descriptions than LP descriptions.

2 - Polynomial Optimization on Algebraic Curves

Mauricio Velasco, Universidad de los Andes, Cra 1 N∫ 18A- 12, Bogota, Colombia, mvelasco@uniandes.edu.co, Greg Blekherman, Gregory Smith

In this talk we describe new asymptotically sharp upper bounds for the degrees of sums of squares multipliers for nonnegative forms on algebraic curves. These bounds give exact polynomial optimization algorithms on curves via their semidefinite programming relaxations.

3 - Semidefinite Relaxations for Tensor Learning

Parikshit Shah, Yahoo! Research Lab, Yahoo! Research Lab, San Jose, CA, United States of America, pshah@discovery.wisc.edu, Gongguo Tang

Tensors provide powerful yet flexible approaches for modeling multi-dimensional data. Important machine learning tasks such as multi-task learning, collaborative filtering, topic modeling, and mixture learning can be modeled naturally via tensors. While tensors are undoubtedly useful, they are also notoriously difficult to work with since basic computational building blocks such as tensor decomposition and tensor rank are intractable. In this talk, I will present some recent work that establishes new, principled, convex optimization based approaches for tensor decomposition and tensor completion.

■ FB05

05- Kings Garden 1

Large Scale Optimization and Preconditioning

Cluster: Nonlinear Programming

Invited Session

Chair: Giovanni Fasano, Assistant Professor, University Ca'Foscari of Venice, Department of Management, S.Giobbe, Cannaregio 873, Venice, VE, 30121, Italy, fasano@unive.it

1 - A General Class of Conjugate Gradient Methods

Mehiddin Al-Baali, Dr., Sultan Qaboos University, Dept. of Mathematics and Statistics, P.O. Box 36, Muscat, 123, Oman, albaali@squ.edu.om

A new class of conjugate gradient methods for large-scale unconstrained optimization will be considered. The class contains most of the well known and recently proposed conjugate gradient methods with standard approximate line search frameworks. A new strategy for enforcing the sufficient descent and global convergence properties of the class will be analysed. Numerical results will be described to illustrate the behaviour of certain members of the class of methods and their modifications (in particular those of the Fletcher-Reeves and Polak-RibiËre). It will be shown that introducing a simple technique to the conjugate gradient methods will improve the performance of the methods substantially.

2 - A Spectral Projected Gradient-Based Method for Image Segmentation

Daniela di Serafino, Prof., Department of Mathematics and Physics, Second University of Naples, viale A. Lincoln, 5, Caserta, I-81100, Italy, daniela.diserafino@unina2.it, Laura Antonelli, Valentina De Simone

We investigate the application of a nonmonotone projected gradient method to a region-based variational model for image segmentation. We consider a “discretize-then-optimize” approach and solve the resulting nonlinear optimization problem by an alternating minimization procedure that exploits the spectral projected gradient method by Birgin, MartÌnez and Raydan. We provide a convergence analysis and perform numerical experiments on several images to evaluate the effectiveness of this procedure. Computational results show that our approach is competitive with a very efficient solver based on the Split Bregman method.

3 - Evolution Strategies for Stochastic Optimization Problems

Soualmi Nacer, CERFACS, 42 Avenue Gaspard Coriolis, Toulouse, 31057, France, soualmi@cerfacs.fr, Luis Nunes Vicente, Serge Gratton

Evolution Strategies (ES) are known to handle well noise and uncertainty in function evaluations. This is due to the fact the points for evaluation are generated randomly within an ensemble or population. However, their greediness in function evaluations is a major limitation in real applications, in particular for higher dimensions. We adapt existing ES for problems where the objective function is formulated stochastically, and where, in addition, the level of noise in function values can be adjustable by varying the computational complexity. We will show that taking the most accurate values can be particularly inappropriate in some instances. Our approach is validated by theoretical and numerical results.

■ FB06

06- Kings Garden 2

Cutting Plane Approaches for Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Ricardo Fukasawa, Associate Professor, University of Waterloo, 200 University Ave West, Waterloo, On, N2L3G1, Canada, rfukasawa@uwaterloo.ca

1 - The Master Equality Polyhedron: Two-Slope Facets and Separation Algorithm

Cathy Wang, University of Waterloo, 619 Wild Ginger Ave. J55, Waterloo, ON, N2V2X1, Canada, cathy.wang@uwaterloo.ca, Ricardo Fukasawa

This talk presents our findings about the Master Equality Polyhedron (MEP), an extension of Gomory's Master Group Polyhedron. We prove a theorem analogous to Gomory and Johnson's two-slope theorem for the case of the MEP. We then show how such theorem can lead to facet defining inequalities for MEPs or extreme inequalities for an extension of the infinite group model. We finally study certain coefficient-restricted inequalities for the MEP and how to separate them.

2 - Single-Row Corner Relaxation with Integral Variables

Alinson Xavier, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L3G1, Canada, axavier@uwaterloo.ca

We study the facial structure of the single-row corner relaxation where the integrality of one or more non-basic variables is preserved. This relaxation can be used to generate cutting planes for general mixed-integer problems. First, we rewrite this set as a constrained two-row corner relaxation, and prove that all its facets arise from a finite number of maximal S-free splits and wedges. Then, we describe an algorithm for enumerating all these facet-defining sets and provide an upper bound on their split rank. Finally, we run computational experiments to compare their strength against MIR cuts.

3 - On Maximal S-Free Sets with the Covering Property

Joseph Paat, Johns Hopkins University, Whitehead Hall, 3400 N. Charles St, Baltimore, MD, 21218, United States of America, jpaat1@jhu.edu, Amitabh Basu

Current algorithms for solving mixed integer programs use cutting planes to approximate the solution set. A collection of these cutting planes can be generated by objects called S-free sets. Certain S-free sets exhibit the ‘covering property’, a tiling-like feature that yields computational tools for creating cutting planes. In this talk, we discuss these ideas, in addition to methods of constructing S-free sets with the covering property.

■ FB07

07- Kings Garden 3

Computation of Economic Equilibrium

Cluster: Variational Analysis

Invited Session

Chair: Vladimir Shikhman, Catholic University of Louvain (UCL), Voie du Roman Pays 34, Louvain-la-Neuve, 1348, Belgium, vladimir.shikhman@uclouvain.be

1 - An Effective Approach to the Determination of Equilibria for Incomplete Asset Markets

Chuangyin Dang, Professor, City University of Hong Kong, Dept. of SEEM, 83 Tat Chee Avenue, Kowloon, Hong Kong - PRC, mecdang@cityu.edu.hk

The difficulty for computing equilibrium of incomplete asset markets arises from the loss of full rank of the asset return matrix. To overcome this difficulty, we formulate the markets as a two-player game consisting of a price player and a consumption player. By introducing an extra variable to incorporate barrier terms into utility functions for both players, we obtain a two-player barrier game that deforms continuously from a trivial game to the original game while the asset return matrix varies from a full-rank trivial one to the original one. The equilibrium conditions of the barrier game yield a smooth path that starts from the unique equilibrium of the trivial game and ends at an equilibrium for the incomplete asset markets.

2 - Algorithm of Price Adjustment for Market Equilibrium

Vladimir Shikhman, Catholic University of Louvain (UCL), Voie du Roman Pays 34, Louvain-la-Neuve, 1348, Belgium, vladimir.shikhman@uclouvain.be, Yurii Nesterov

We suggest an algorithm for price adjustment towards a partial market equilibrium. Its convergence properties are crucially based on Convex Analysis. Our price adjustment corresponds to a subgradient scheme for minimizing a special nonsmooth convex function. This function is the total excessive revenue of the market's participants, and its minimizers are equilibrium prices. As the main result, the algorithm of price adjustment is shown to converge to equilibrium prices. Additionally, a market equilibrium clears on average during the price adjustment process. Moreover, an efficient rate of convergence is obtained.

■ FB08

08- Kings Garden 4

Information and Sparse Optimization

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Deanna Needell, Claremont McKenna College, 850 Columbia Ave, Claremont, CA, 91711, dneedell@cmc.edu

1 - Convergence Theory for Subspace Estimation from Undersampled Data

Laura Balzano, University of Michigan, 1301 Beal Ave, Ann Arbor, MI, 48109, United States of America, girasole@umich.edu

Non-convex problem formulations in matrix factorization sometimes lead to faster algorithms empirically, yet we are only recently beginning to understand general convergence theory for these problems. In this talk we will discuss algorithms and theory for solving non-convex formulations of subspace estimation and union of subspaces estimation problems. We consider the context where data are undersampled, where SVD methods for subspace estimation do not directly apply. SVD methods may be applied by generalizing the notion of projections to the case where data are undersampled. This leads to a tradeoff between convergence rate and undersampling rate. We demonstrate our methods on data in computer vision and network topology identification.

2 - Constrained Adaptive Sensing

Deanna Needell, Claremont McKenna College, 850 Columbia Ave, Claremont, CA, 91711, dneedell@cmc.edu

Suppose that we wish to estimate a vector from a small number of noisy linear measurements. When the vector is sparse, one can obtain a significantly more accurate estimate by adaptively selecting the samples based on the previous measurements. In this talk we consider the case where we wish to realize the benefits of adaptivity but where the samples are subject to physical constraints. We demonstrate both the limitations and advantages of adaptive sensing in this constrained setting.

3 - Practical Quantization and Encoding of Compressed Sensing Measurements: Exponential Accuracy

Rayan Saab, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA, 92093, United States of America, rsaab@ucsd.edu

In the era of digital computation, data acquisition consists of a series of steps. A sampling or measurement process is typically followed by quantization, or digitization. In turn, quantization is often followed by encoding, or compression, to efficiently represent the quantized data. In this talk, we propose quantization and encoding schemes for compressed sensing, along with associated reconstruction algorithms based on convex optimization. Our methods, which also work in the extreme case of 1-bit quantization, yield near-optimal approximation accuracy as a function of the bit-rate while preserving the stability and robustness properties of standard compressed sensing schemes. Joint work with Rongrong Wang and Ozgur Yilmaz.

■ FB09

09- Kings Garden 5

Topics in Robust Optimization III

Cluster: Robust Optimization

Invited Session

Chair: Angelos Georghiou, ETH Zurich, Physikstrasse 3, ETL K 12, Zurich, 8037, Switzerland, angelosg@control.ee.ethz.ch

1 - Robust Optimization of Trusses under Dynamic Loads via Nonlinear Semidefinite Programming

Anja Kuttich, TU Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, kuttich@mathematik.tu-darmstadt.de, Stefan Ulbrich

We consider the problem of truss topology design with respect to uncertainty in time-dependent loads via robust optimization. To evaluate the stability and stiffness of truss structures we use the mean square displacement as a suitable objective function, which allows for an efficient calculation of a worst-case scenario. We use the H-infinity norm of the transfer-function for the worst-case objective function and the Bounded-Real Lemma to obtain a nonlinear semidefinite programming problem. We present numerical results.

2 - Robust Perfect Matching Problem

Viktor Bindewald, Technische Universitaet Dortmund, Fakultaet fuer Mathematik, Vogelpothsweg 87, Mathematik, TU Dortmund, Dortmund, 44227, Germany, viktor.bindewald@math.tu-dortmund.de, Dennis Michaels, David Adjiashvili

We study theoretical and algorithmically applicable properties of the following structural robust combinatorial problem. Given a graph $G=(V,E)$ and subsets of E, each constituting a scenario in which the specified edges fail and are removed from G. The objective is to find a minimum cardinality edge set containing a perfect matching for every scenario. We focus on bipartite graphs with two single failing edges and the setting where every edge can fail.

3 - Multistage Adaptive Mixed-Integer Optimization

Angelos Georghiou, ETH Zurich, Physikstrasse 3, ETL K 12, Zurich, 8037, Switzerland, angelosg@control.ee.ethz.ch, Dimitris Bertsimas

In recent years, decision rules have been established as the preferred solution method for addressing the computationally demanding, multistage adaptive optimization problems. Despite their success, existing decision rules (a) are typically constrained by their a priori design and (b) do not incorporate in their modelling adaptive binary decisions. In this talk, we present a methodology for the near optimal design of continuous and binary decision rules using mixed-integer optimization.

■ FB10

10- Kings Terrace

Optimization with Nonlinear Risk Measures

Cluster: Finance and Economics

Invited Session

Chair: Alexander Vinel, The University of Iowa, 3131 Seamans Center for the Engineering, and Sciences, Iowa City, IA, 52242, United States of America, alexander-vinel@uiowa.edu

1 - Certainty Equivalent Measures of Risk

Alexander Vinel, The University of Iowa, 3131 Seamans Center for the Engineering, and Sciences, Iowa City, IA, 52242, United States of America, alexander-vinel@uiowa.edu, Pavlo Krokhmal

We study a framework for constructing coherent and convex measures of risk which is inspired by infimal convolution operator, and prove that the proposed approach constitutes a new general representation of these classes. We then discuss how this scheme may be eeffectively employed to obtain a class of certainty equivalent measures of risk that can directly incorporate decision maker's preferences as expressed by utility functions. This approach is consequently employed to introduce a new family of measures, the log-exponential convex measures of risk. Conducted numerical experiments show that this family can be a useful tool when modeling risk-averse decision preferences under heavy-tailed distributions of uncertainties.

2 - A Scenario Decomposition Algorithm for Stochastic Programming Problems with a Class of Downside Risk

Maciej Rysz, NRC - AFRL, 1350 N. Poquito Road, Shalimar, FL, United States of America, mwrysz@yahoo.com, Pavlo Krokhmal, Eduardo Pasiliao, Alexander Vinel

We present an efficient scenario decomposition algorithm for solving large-scale convex stochastic programming problems that involve a particular class of downside risk measures. The considered risk functionals encompass coherent and convex measures of risk that can be represented as an infimal convolution of a convex certainty equivalent. The resulting structure of the feasible set is then exploited via iterative solving of relaxed problems, and it is shown that the number of iterations is bounded by a parameter that depends on the problem size. The computational performance of the developed scenario decomposition method is illustrated on portfolio optimization problems involving two families of nonlinear measures of risk.

3 - Risk-Averse Strategic Planning of HVDC Renewable Energy Grids

Bo Sun, University of Iowa, 4219 Seamans Center, Iowa City, IA, 52242, United States of America, bo-sun-1@uiowa.edu, Yong Chen, Pavlo Krokhmal

We consider the problem of risk-averse strategic planning of high-voltage direct current (HVDC) grids. HVDC transmission systems offer significant advantages comparing to the traditional AC transmissions. We discuss the problem of long-term (strategic) planning of HVDC grids that incorporate sources of renewable energy, such as large-scale wind farms. Risks of power shortages are controlled using nonlinear higher-moment coherent risk (HMCR) measures. Solution methods for the resulting mixed-integer programming problems and computational case studies are presented.

■ FB11

11- Brigade

Models of Traffic and Traffic Equilibrium

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Sebastien Blandin, IBM Resarch, IBM Singapore, 9 Changi Business Park Ce, The IBM Place, Singapore, 486048, Singapore, sblandin@sg.ibm.com

1 - Fast Optimal Traffic Control for Incidents

Laura Wynter, IBM Research, IBM Singapore, 9 Changi Business Park, Singapore, Singapore, lwynter@sg.ibm.com, Saif Jabari, Sebastien Blandin, Charles Brett

The convergence of ubiquitous sensing has permitted more computationally efficient methods for traffic control on road networks so as to operate in real-time in a live environment. In this work, we present a new fast decomposition method for network optimization problems, with application to real-time traffic control and in particular for traffic control re-optimization during incident conditions. Our approach is based on an observation that the nonlinear programming formulation can be recast in a much simpler form, leading to an order of magnitude improvement.

2 - Tolled User Equilibria of Macroscopic Traffic Flow Models in the Context of Prospect Theory

Sebastien Blandin, IBM Resarch, IBM Singapore, 9 Changi Business Park Ce, The IBM Place, Singapore, 486048, Singapore, sblandin@sg.ibm.com, Thomas Palomares

In this work, we consider the problem of modeling choice in a network game with preferences that follows the axioms of prospect theory, and when the underlying behavioral model is a scalar partial differential equation. The choice function includes convex-concave response to the stimulus. Under natural assumptions, we extend existing results based on monotonic cost functions, and prove the existence of a "maximal" Nash equilibrium (definition introduced in this work) under any response scheme, and we exhibit necessary and sufficient conditions for its uniqueness. Numerical results are also presented.

3 - Optimal Base Stations Location and Configuration for Cellular

Shokri Selim, Professor, King Fahd University of Petroleum & Mineral, Department of systems engineering, King Fahd University of Petroleum & Mine, Dhahran, 31261, Saudi Arabia, selim@kfupm.edu.sa, Mansour Aldajani, Yasser Almoghathawi

We study the problem of base stations location and configuration. Antenna configuration includes number of antennas installed at the base station, the azimuth of each base station, tilt, height, and transmitted power for each antenna for cellular mobile networks. An integer program. The objective of the model is to minimize the cost of the network. The model guarantees that each demand point is covered. A demand point represents a cluster of uniformly distributed multiple users. In addition, the signal-to- noise ratio at each demand point is set at a given threshold value. To illustrate the capability of the formulated IP model, we use a discretized map of some area with demand points. The IP model is solved using a commercial software.

■ FB13

13- Rivers

Some Applications Based on Cone Programming

Cluster: Conic Programming

Invited Session

Chair: Yu Xia, Assistant Professor, Lakehead University, 955 Oliver Rd., Thunder Bay, ON, P7B 5E1, Canada, yxia@lakeheadu.ca

1 - Appointment Scheduling with Unpunctuality

Zhichao Zheng, Singapore Management University, Lee Kong Chian School of Business, 50 Stamford Road, Singapore, 178899, Singapore, danielzheng@smu.edu.sg, Chung Piaw Teo, Qingxia Kong, Chung-Yee Lee

Typical healthcare appointment scheduling problems assume that patients arrive punctually according to assigned appointment time, which is rarely true in practice, especially in outpatient clinics. We study the design of healthcare appointment system when patient arrivals deviate from the scheduled appointment time by a random amount. We use a network flow model to capture the dynamics of the system and develop a copositive optimization model to solve the appointment scheduling problem. Our analysis using clinical data suggests it is important to account for patient unpunctuality in the design of appointment policies.

2 - Object Oriented Geometric Programming in Python

Edward Burnell, Graduate Student Researcher, MIT, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, eburn@mit.edu, Warren Hoburg

We present GPkit, an open source modeling package for geometric programming (GP), written in Python. GPkit gives users the ability to quickly construct GP models for a wide range of engineering applications. Features include monomial and posynomial substitutions, unit checking and conversions, interactive explorations, sweeps over Pareto-optimal design spaces, and support of reusable object-oriented GP models.

3 - Second-Order Cone Programming for P-Spline Simulation Metamodeling

Yu Xia, Assistant Professor, Lakehead University, 955 Oliver Rd., Thunder Bay, ON, P7B 5E1, Canada, yxia@lakeheadu.ca, Farid Alizadeh

This paper approximates simulation models by B-splines with a penalty on high-order finite differences of the coefficients of adjacent B-splines. The penalty prevents overfitting. The simulation output is assumed to be nonnegative. The nonnegative spline simulation metamodel is casted as a second-order cone programming problem, which can be solved efficiently by modern optimization techniques. The method is implemented in MATLAB.

FB14

14- Traders

Game Theory

Cluster: Game Theory

Invited Session

Chair: Gomatam Ravindran, Associate Professor, Indian Statistical Institute, 110, Nelson Manickam Road, Chennai, Chennai, 600029, India, ravi@isichennai.res.in

1 - "And the Winners are..." – Impartial Selection of More than One

Antje Bjelde, TU Berlin, Str. des 17. Juni 136, Berlin, 10623, Germany, bjelde@math.tu-berlin.de, Max Klimm, Felix Fischer

We study the problem of selecting k agents based on nominations made within their group. A selection mechanism is called impartial if no agent can alter its own probability of being selected by changing its nominations. We are interested in approximating the number of nominations the selected agents received and present tight results for deterministic respectively universally impartial mechanisms for the case k=2. For general k, lower and upper bounds on the performance of any impartial mechanism are given.

2 - Cooperative Games on Intersecting Families

Ayumi Igarashi, University of Oxford, Wolfson Building, Parks Road, Oxford, United Kingdom, ayumi.igarashi@cs.ox.ac.uk, Yoshitsugu Yamamoto

Recent years have seen a growing interest in cooperative games on subfamilies. By defining a game on a subfamily of subsets of players that satisfy certain axioms, it has become possible to grasp proposed solution concepts from a more general view. One of the issues in this line of research, however, is that the standard definition of supermodular games is no longer applicable to such general situations. In this paper, we introduce the relaxed notion of supermodularity for games on subfamilies, called quasi-supermodularity, and show that the class of intersecting families is a maximal class to preserve supermodularity for the extended games. We also investigate the properties of game theoretic solutions for these games.

3 - On the Game Theoretic Value of a Linear Transformation on a Self-Dual Cone

Gomatam Ravindran, Associate Professor, Indian Statistical Institute, 110, Nelson Manickam Road, Chennai, Chennai, 600029, India, ravi@isichennai.res.in, Muddappa Seetharama Gowda

We present generalisation of the concept of a value of (zero-sum) matrix game. Given a finite dimensional real inner product space V with a self dual cone K, an element e in the interior of K, and a linear transformation L, we define the value of L as the minimax value v(L) by := max min (L(x), y)= min max(L(x), y) (x and y each vary over K with (x,e)=1 and (y,e)=1. We extend some classical results of Kaplansky and Raghavan. In addition for a Z-transformation (which is a generalisation of Z - matrix), we relate the value with various properties such as positive stable property, the S-property etc. We apply these results to find the values of the L_A and and S_A on the cone of nXn real positive semidefinite matrices.

FB15

15- Chartiers

Global Optimization: Algorithms and Applications

Cluster: Global Optimization

Invited Session

Chair: Hong Seo Ryoo, Professor, Korea University, 145 Anam-Ro, Seoungbuk-Gu, Seoul, 136-713, Korea, Republic of, hsryoo@korea.ac.kr

1 - Box Clustering and Logical Analysis of Data

Paolo Serafini, Prof., University of Udine, Dipartimento di Matematica e Informatica, Via delle Scienze 206, Udine, UD, 33100, Italy, paolo.serafini@uniud.it, Giuseppe Lancia, Franca Rinaldi

We address the problem of classifying data via box clustering. The data are in general integer-valued vectors. In the particular case they are binary vectors, like in Logical Analysis of Data, boxes can be identified with strings of 0's, 1's and wild cards which can take either the value 0 or the value 1. The classification calls for covering the positive data, while not hitting any negative data, with a set of boxes that is at the same time of minimal cardinality and of maximum redundancy. The mathematical programming model to solve the problem is based on column generation. The resulting branch-and-price scheme requires special branching techniques in order to increase the efficiency of the branch-and-bound tree search.

2 - Optimization via Clustering in Machine Learning

Young Woong Park, Northwestern University, 2145 Sheridan Rd, Evanston, IL, United States of America, ywpark@u.northwestern.edu, Diego Klabjan

We propose a clustering-based iterative algorithm to solve certain optimization problems, where we start the algorithm by aggregating the original data, solving the problem on aggregated data, and then in subsequent steps gradually disaggregate the aggregated data. We apply the algorithm to common machine learning problems such as the least absolute deviation regression, support vector machine, and semi-supervised support vector machine. We derive model-specific data aggregation and disaggregation procedures. We also show optimality, convergence, and the optimality gap of the approximated solution.
A computational study is provided.

3 - A Rectified LAD for Numerical Data

Cui Guo, Associate Professor, Shantou University, 243 Da Xue Road, Shantou, China, cguo@stu.edu.cn, Hong Seo Ryoo

LAD presents some limitations when analyzing numerical data, owing to a difference in structural properties of originally 0-1 data and binarized 0-1 data. This paper illustrates these limitations and develops a way to rectify the general LAD framework to more accurately analyze numerical data.

FB16

16- Sterlings 1

Advances in Stochastic Dynamic Programming

Cluster: Stochastic Optimization

Invited Session

Chair: David Brown, Duke University, 100 Fuqua Drive, Durham, NC, 27708, United States of America, dbbrown@duke.edu

1 - Decomposable Markov Decision Processes: A Fluid Optimization Approach

Velibor Misic, Operations Research Center, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-149, Cambridge, MA, 02139, United States of America, vvmisic@mit.edu, Dimitris Bertsimas

Decomposable MDPs are problems where the system and its dynamics can be decomposed along multiple components. We propose a fluid optimization approach for such problems that achieves tractability by exploiting decomposability. We show that this approach achieves strong performance in restless bandit problems, optimal stopping problems and network revenue management.

2 - Tax-Aware Dynamic Asset Allocation

Martin Haugh, Associate Professor, Columbia University, 500 West 120th Street, Room 332, New York, NY, 10027, United States of America, mh2078@columbia.edu, Chun Wang, Garud Iyengar

We consider dynamic asset allocation problems where the investor is required to pay capital gains taxes on her investment gains. This is a very challenging problem because the tax to be paid whenever a security is sold depends on the tax basis, i.e. the price(s) at which the security was originally purchased. This feature results in high-dimensional and path-dependent problems which cannot be solved exactly except in the case of very stylized problems with just one or two securities and relatively few time periods. We develop several sub-optimal trading policies for these problems and use duality techniques based on information relaxations to assess their performances.

3 - Information Relaxation Bounds for Infinite Horizon Markov Decision Processes

David Brown, Duke University, 100 Fuqua Drive, Durham, NC, 27708, United States of America, dbbrown@duke.edu, Martin Haugh

We study infinite horizon MDPs with discounted costs and develop a general approach for calculating performance bounds using information relaxations. We discuss ways to make the approach computationally manageable on problems with large state spaces and study the quality of the resulting bounds: the approach provably improves upon bounds from "Bellman feasible" approximate value functions. We apply the approach to the problem of dynamic service allocation in a multiclass queue. In our examples, we find the information relaxation lower bounds are relatively easy to calculate and are very close to the upper bounds obtained from simple heuristic policies.

■ FB17

17- Sterlings 2

Multi-Stage and Multi-Level Optimization for Treatment Decisions in Healthcare Applications

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Marina Epelman, University of Michigan, Industrial and Operations Engineering, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, mepelman@umich.edu

1 - Biomarker-Based Two-Stage Stochastic Optimization Treatment Planning Models in Radiation Therapy

Marina Epelman, University of Michigan, Industrial and Operations Engineering, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, mepelman@umich.edu, Troy Long, Victor Wu, Edwin Romeijn, Martha Matuszak

Intensity Modulated Radiation Therapy is a common cancer treatment technique that uses external beams of radiation to deliver non-homogeneous intensity patterns to a patient from multiple stationary locations. Treatment planners optimize a physician's treatment planning goals while satisfying the constraints of the treatment modality using information obtained pre-treatment. Increasingly, biomarker data obtained during treatment is shown to provide patient-specific information on response to radiation and predisposition to radiation-induced side effects. We explore two-stage stochastic optimization models for adaptive treatment planning to improve patient outcomes, with examples from lung and liver cancer cases.

2 - Copayment Restructuring for a Heterogeneous Patient Population

Gregg Schell, University of Michigan, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, schellg@umich.edu, Mariel Lavieri

Operations research has contributed heavily to the derivation of optimal treatment guidelines for chronic disease. However, this research has assumed that patients will follow the optimal guidelines. Targeted incentives have the potential to improve patient adherence to the guidelines. To determine the optimal allocation of incentives across a heterogeneous patient population, we formulate a bilevel optimization problem with constraints on resource availability as well as maximum inequity.

3 - Optimal Learning of Dose-Response from a Cohort

Jakob Kotas, University of Washington, Box 353925, Seattle, WA, 98195, United States of America, jkotas@uw.edu, Archis Ghate

We present a stochastic dynamic programming (DP) framework for learning a dose-response parameter while optimally dosing a cohort of patients. Solution of Bellman's equations for this problem is computationally intractable, so we explore two approximation methods: certainty equivalent control (CEC) and semi-stochastic CEC. Under natural assumptions on the underlying functions, we prove properties of these approximate methods, including convexity, separation of the problem across patients, and monotonicity and stationarity of the optimal dosing policy. Numerical results using data from a clinical trial on rheumatoid arthritis will be discussed.

■ FB18

18- Sterlings 3

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: James Hungerford, Experienced Researcher, MINO Initial Training Network, M.A.I.O.R., 512 Via San Donato, Lucca, LU, Italy, jamesthungerford@gmail.com

1 - A Strongly Polynomial Simplex Method for Totally Unimodular LP

Shinji Mizuno, Professor, Tokyo Institute of Technology, 2-12-1-W9-58 Oo-Okayama, Meguro, Tokyo, Japan, mizuno.s.ab@m.titech.ac.jp

We combine results of Kitahara and Mizuno for the number of distinct solutions generated by the simplex method and Tardos's strongly polynomial algorithm. We propose an algorithm for solving a standard form LP problem. The algorithm solves polynomial number of auxiliary LP problems by the simplex method with Dantzig's rule. It is shown that the total number of distinct basic solutions generated by the algorithm is polynomially bounded in the number of constraints, the number of variables, and the maximum determinant of submatrices of a coefficient matrix.

2 - The Continuous Quadratic Knapsack Problem

James Hungerford, Experienced Researcher, MINO Initial Training Network, M.A.I.O.R., 512 Via San Donato, Lucca, LU, Italy, jamesthungerford@gmail.com, William Hager, Tim Davis

The continuous quadratic knapsack problem (CQK) is to minimize a separable convex quadratic function subject to a box constraint and a knapsack constraint. The CQK arises as a subproblem in many areas of optimization, including network flows, graph partitioning, and quadratic resource allocation. Most algorithms assume the objective function is strictly convex and are based on finding a root of the derivative of the dual function, a piecewise linear function with 2n breakpoints. In this talk, we survey the available methods for solving the CQK, and show how one of these methods, known as the variable fixing method, can be extended to the case where the objective function is non-strictly convex. Numerical results are presented.

■ FB19

19- Ft. Pitt

Multiunit Auctions

Cluster: Game Theory

Invited Session

Chair: Mariann OllarPostdoctoral Research , Associate 160 McNeil Building, 3718 Locust Walk, Philadelphia, PA, 19104, United States of America, omariannwisc@gmail.com

1 - Simple Auctions with Simple Strategies

Jamie Morgenstern, Postdoctoral Researcher, University of Pennsylvania, 337 Roup Ave, Pittsburgh, Pe, 152321011, United States of America, jamiemmt@cs.cmu.edu, Nikhil R. Devanur, Seth Matthew Weinberg, Vasilis Syrgkanis

We introduce single-bid auctions as a new format for combinatorial auctions. In single-bid auctions, each bidder submits a single real-valued bid for the right to buy items at a fixed price. In this auction format, bidders can implement no-regret learning strategies for single-bid auctions in polynomial time. Price of anarchy bounds for correlated equilibria concepts in single-bid auctions therefore have more bite than their counterparts for auctions and equilibria for which learning is not known to be computationally tractable. To this end, we show that for any subadditive valuations the social welfare at equilibrium is an O(log m)-approximation to the optimal social welfare, where m is the number of items.

2 - Pay-as-Bid: Selling Divisible Goods to Uninformed Bidders

Kyle Woodward, UCLA, Economics Department, Los Angeles, United States of America, kwoodward@ucla.edu, Marek Pycia

Pay-as-bid is the most popular auction format for selling treasury securities. We prove the uniqueness of pure-strategy Bayesian-Nash equilibria in pay-as-bid auctions where symmetrically-informed bidders face uncertain supply, and we establish a tight sufficient condition for the existence of this equilibrium. Equilibrium bids have a convenient separable representation: the bid for any unit is a weighted average of marginal values for larger quantities. We leverage our representation of bids to show that when maximizing revenue, selecting supply is more effective than selecting a reserve price. With optimal supply and reserve price, the pay-as-bid auction is revenue-equivalent to the uniform-price auction.

3 - Privacy-Preserving Market Design

Mariann Ollar, Postdoctoral Research Associate, University of Pennsylvania, 160 McNeil Building, 3718 Locust Walk, Philadelphia, PA, 19104, United States of America, ollar@sas.upenn.edu, Ji Hee Yoon, Marzena Rostek

Privacy is a concern in auctions and exchanges. We formulate a market design problem restricting to uniform-price market clearing to study the joint design of feedbacks (Observables); contingent bids (Contingent Variables) and the timing of market clearings. A design preserves privacy if the observable outcomes are not sufficient to recover the participants' private information before the relevant bidding stage. In a quadratic Gaussian Double Auction environment, we show that this minimal privacy requirement is generically necessary for exchange. Yet, there need not be a trade-off between privacy and welfare in that privacy-preserving designs with rich set of conditionals can be efficient.

■ FB20

20- Smithfield

Randomized, Distributed, and Primal-Dual Methods I

Cluster: Nonsmooth Optimization

Invited Session

Chair: Peter Richtarik, Professor, University of Edinburgh, Peter Guthrie Tait Road, EH9 3FD, Edinburgh, EH9 3FD, United Kingdom, peter.richtarik@ed.ac.uk

1 - Constrained Convex Minimization via Model-Based Excessive Gap

Volkan Cevher, Laboratory for Information and Inference Systems (LIONS), EPFL, Switzerland, EPFL STI IEL LIONS, ELE 233 (B,timent ELE) Station 11, Lausanne, 1015, Switzerland, volkan.cevher@epfl.ch, Quoc Tran-Dinh

We introduce a model-based excessive gap technique to analyze first-order primal-dual methods for constrained convex minimization. As a result, we construct new primal-dual methods with optimal convergence rates on the objective residual and the primal feasibility gap of their iterates separately. Through a dual smoothing and prox-function selection strategy, our framework subsumes the augmented Lagrangian, and alternating methods as special cases, where our rates apply.

2 - Stochastic Dual Newton Ascent for Empirical Risk Minimization

Peter Richtarik, Professor, University of Edinburgh, Peter Guthrie Tait Road, EH9 3FD, Edinburgh, EH9 3FD, United Kingdom, peter.richtarik@ed.ac.uk, Zheng Qu, Martin Takac, Olivier Fercoq

We propose a new algorithm for minimizing regularized empirical loss: Stochastic Dual Newton Ascent (SDNA). Our method is dual in nature: in each iteration we update a random subset of the dual variables. However, unlike existing methods such as stochastic dual coordinate ascent, SDNA is capable of utilizing more or all of curvature information contained in the examples, which leads to striking improvements in both theory and practice - sometimes by orders of magnitude. In the case of ridge regression, our method can be interpreted as a novel variant of the recently introduced Iterative Hessian Sketch.

3 - Communication-Efficient Distributed Optimization of Self-Concordant Empirical Loss

Lin Xiao, Microsoft Research, Machine Learning Groups, Redmond, WA, 98052, United States of America, Lin.Xiao@microsoft.com, Yuchen Zhang

We propose a communication-efficient distributed algorithm for large-scale empirical risk minimization in machine learning. The algorithm is based on an inexact damped Newton method, where the Newton steps are computed by a distributed preconditioned conjugate gradient method. We analyze its iteration complexity and communication efficiency for minimizing self-concordant empirical loss functions. In a standard setting for supervised learning where the problem condition number grows with the total sample size, the required number of communication rounds of our algorithm does not increase with the sample size, but only grows slowly with the number of machines in the distributed system.

■ FB21

21-Birmingham

MINLPs in Gas Network Optimization

Cluster: Optimization in Energy Systems

Invited Session

Chair: Alexander Martin, FAU Erlangen-Nürnberg, Department Mathematik, Cauerstr 11, Erlangen, Germany, alexander.martin@math.uni-erlangen.de

1 - Legal Physics: Modelling Contracts on Gas Networks – The KWP Tool

Thorsten Koch, Prof. Dr., ZIB / TU Berlin, Takustr. 7, Berlin, 14195, Germany, koch@zib.de

Germany decided to end nuclear power and conduct an energy turnaround. While renewables shell account for the majority of the electricity, the plan calls for gas power station to absorb peak loads. Due to the unbundling of gas transport and gas trading by the EU, the transport system operators are now required to reliably provide large amounts of gas to the newly build power stations on very short notice. Extending the network costs about 1 Mio €per km. The new KWP contract allows coping with this situation much more efficiently on a pure legal basis. But it also means you need a robust solution to a large-scale stochastic mixed-integer non-linear optimization problem every day. We will try to describe the problem and possible solutions.

2 - Technical Capacities of Gas Networks and their Impact on Market Design

Lars Schewe, Friedrich-Alexander-Universitaet Erlangen-Nürnberg (FAU), Cauerstrafle 11, 91058 Erlangen, Germany, Lars.Schewe@math.uni-erlangen.de

Under the current European entry-exit system for trading of gas network capacities, so-called technical capacities (i.e. the capacities that can be transported by the network) are at the heart of the capacity market. We show that the computation of technical capacities in a gas network under current regulations can be posed as a multi-stage mixed-integer nonlinear optimization problem. We discuss the hardness of the problem and propose an approximation approach. Furthermore, the impact of these results on the current design of the capacity market.

3 - Solving Power-Constrained Gas Transport Problems using an MIP-based Alternating Direction Method

Martin Schmidt, Friedrich-Alexander-Universitaet Erlangen-Nürnberg, Cauerstrafle 11, Erlangen, 91058, Germany, mar.schmidt@fau.de, Lars Schewe, Antonio Morsi, Bjoern Geifller

We present an algorithm for problems from gas transport. Due to nonconvex physics as well as discrete controllability of active devices, these problems lead to hard nonconvex MINLPs. Our method is based on MIP techniques using piecewise linear relaxations of the nonlinearities and a tailored alternating direction method. In addition to most other publications in the field of gas transport optimization, we do not only consider pressure and flow as main physical quantities but further incorporate heat power supplies and demands as well as a mixing model for different gas qualities. We demonstrate the capabilities of our method by numerical results on the largest instances that were ever reported in the literature for this problem class.

■ FB22

22- Heinz

Polynomial Root Minimization, Accelerating Projection Algorithms, and Self-Contracted Curves

Cluster: Variational Analysis

Invited Session

Chair: C.H. Jeffrey Pang, Assistant Professor, National University of Singapore, Mathematics, Blk S17, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, matpchj@nus.edu.sg

1 - Accelerating Projection Algorithms: Greediness and Nonconvexity

C.H. Jeffrey Pang, Assistant Professor, National University of Singapore, Mathematics, Blk S17, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, matpchj@nus.edu.sg

The feasibility problem (i.e., finding a point in the intersection of several convex/nonconvex sets) is typically solved by the method of alternating projections. If the sets were convex, we can project onto to these sets to obtain supporting halfspaces, and then project onto the intersection of these halfspaces using standard methods in quadratic programming to accelerate convergence. This strategy can give multiple-term superlinear convergence for convex problems. We show how to design "greedy" algorithms that have such superlinear convergence, and show how to extend the algorithm for nonconvex super-regular sets in the sense of Lewis-Luke-Malick.

2 - Self-Contracted Curves and Applications

Aris Daniilidis, Profesor Titular, Universidad de Chile, Departamento de Ingenerìa Matematica, Blanco Encalada 2120, piso 5, oficina 523, Santiago, Chile, arisd@dim.uchile.cl

The notion of self-contracted curve is tightly related to convexity. Given a convex function, self-contracted curves appear naturally as solutions (orbits) of its corresponding (sub)gradient dynamical system, or as polygonal curves determined by the proximal algorithm under any choice of parameters. In this talk, we discuss asymptotic properties of such curves in Euclidean spaces and their applications.

3 - Polynomial Root Radius Optimization with Affine Constraints

Julia Eaton, Assistant Professor, University of Washington Tacoma, Interdisciplinary Arts and Sciences, Campus Box 358436, 1900 Commerce Street, Tacoma, WA, 98402, United States of America, jreaton@uw.edu, Sara Grundel, Mert Gurbuzbalaban, Michael L. Overton

The root radius of a polynomial is the maximum of the moduli of its roots (zeros). We consider the following optimization problem: minimize the root radius over monic polynomials of degree n, with either real or complex coefficients, subject to k consistent affine constraints on the coefficients. We show that there always exists an optimal polynomial with at most $k-1$ inactive roots, that is, whose moduli are strictly less than the optimal root radius. We illustrate our results using some examples arising in feedback control.

■ FB23

23- Allegheny

The Lovasz Local Lemma

Cluster: Combinatorial Optimization

Invited Session

Chair: Nicholas Harvey, University of British Columbia, ICICS/CS Building, 2366 Main Mall, Vancouver, BC, V6T 1Z4, Canada, nickhar@cs.ubc.ca

1 - An Algorithmic Proof of the Lopsided Lovasz Local

Nicholas Harvey, University of British Columbia, ICICS/CS Building, 2366 Main Mall, Vancouver, BC, V6T 1Z4, Canada, nickhar@cs.ubc.ca, Jan Vondrak

The breakthrough results of Moser and Tardos give algorithmic forms of the Lovasz Local Lemma when the probability space is defined by independent variables. We give a new algorithmic form of the local lemma for more general probability spaces, assuming only a "resampling oracle" for each event. We show that the existence of resampling oracles is equivalent to a positive association property similar to the assumptions of the "lopsided local lemma". In particular, efficient resampling oracles can be designed for the known application scenarios of the lopsided local lemma (random permutations, matchings, spanning trees). We present several new algorithmic results in these scenarios.

2 - Finding Global Optima by Randomized Local Search

Fotis Iliopoulos, UC Berkeley, EECS, Berkeley, CA, 95129, United States of America, fotis.iliopoulos@berkeley.edu, Dimitris Achlioptas

At the heart of every local search procedure is a directed graph on candidate solutions (states) such that every unsatisfying state has at least one outgoing arc. In randomized local search the hope is that a random walk on the graph reaches a satisfying state (sink) quickly. We give a general algorithmic local lemma by establishing a sufficient condition for this to be true. Our work is inspired by Moser's entropic method proof of the Lov\'{a}sz Local Lemma (LLL) for satisfiability and completely bypasses the Probabilistic Method formulation of the LLL. In particular, our method allows both the search space and the optimality conditions to be entirely amorphous, enabling the analysis of far more sophisticated algorithms than the LLL. Similarly to Moser's argument, the key point is that algorithmic progress is measured in terms of entropy rather than in terms of energy (number of violated constraints) so that termination can be established even under the proliferation of local optima. The talk assumes no familiarity with the LLL or the Probabilistic Method.

■ FB24

24- Benedum

Lifting and Mixed-Integer Quadratic Programming

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Emiliano Traversi, University of Paris 13, 99 Avenue Jean-Baptiste Clément, Villetaneuse, France, emiliano.traversi@gmail.com

1 - Approximated Perspective Relaxations: A Project & Lift Approach

Fabio Furini, LAMSADE - Universite' Paris Dauphine, Place du Maréchal de Lattre de Tassigny, Paris, France, fabio.furini@dauphine.fr, Antonio Frangioni, Claudio Gentile

The Perspective Reformulation (PR) of a Mixed-Integer NonLinear Program with semi-continuous variables is obtained by replacing each term in the (separable) objective function with its convex envelope. Solving the corresponding Perspective Relaxation requires appropriate techniques. While the AP2R bound can be weaker than that of the PR, this approach can be applied in many more cases and allows direct use of off-the-shelf MINLP software; this is shown to be competitive with previously proposed approaches in many applications.

2 - QPLIB, a library of Quadratic Programming Instances

Emiliano Traversi, University of Paris 13, 99 Avenue Jean-Baptiste Clément, Villetaneuse, France, emiliano.traversi@gmail.com, Fabio Furini

In this work we present a library of Quadratic Programming Instances (QPLIB). Quadratic programming problems have received an increasing amount of attention in recent years, both from theoretical and practical points of view. This category of problems is particularly important, since quadratic programs model many real-world classes of problems. The QPLIB balances instances from real-world applications and academic problems, obtained after a call for instances using a variety of means of communication. The QPLIB aims at being used as reference for the community and the practitioner involved in QP.

■ FB25

25- Board Room

Models and Algorithms for Commitment and Dispatch

Cluster: Optimization in Energy Systems

Invited Session

Chair: Uday Shanbhag, Pennsylvania State University, 353 Leonhard Building, University Park, PA, 16802, United States of America, udaybag@psu.edu

1 - Deriving Utility Functions from Revealed Preference Data

Daniel Ralph, University of Cambridge, Judge Business School, Cambridge, United Kingdom, d.ralph@jbs.cam.ac.uk, Jean-Pierre Crouzeix, Andrew Eberhard

Some decades ago, Afriat showed that a finite sample of revealed preference data that satisfy some standard economic axioms, such as the Generalised Axiom of Revealed Preference, can be used to construct a concave utility function that is consistent with the data. We ask what happens when the sample is infinite, which takes us out of the realm of convex analysis into quasiconvex and pseudoconvex analysis. This relates to a problem of integration which is to recover a pseudoconvex function from the normal cones to its level sets. We focus on existence of solutions to these problems.

2 - A Scalable Primal-Dual Method for the Two-Stage Stochastic Unit Commitment Problem

Farzad Yousefian, Pennsylvania State University, 224 Leonhard Building, University Park, PA, 16802, United States of America, szy5@psu.edu, Uday Shanbhag

We consider a two-stage unit commitment scheduling problem capturing the uncertainties in demand and availability with nonlinear costs. The resulting mathematical model is a possibly large-scale stochastic mixed integer nonlinear program; unfortunately, commercial packages, e.g. CPLEX struggle to accommodate nonlinearity and uncertainty in a scalable fashion. We develop a scalable primal-dual method for obtaining KKT points of smoothed counterparts. Preliminary simulation results are presented.

3 - Multi-Stage Generation and Transmission Co-Planning under Uncertainty

Benjamin Hobbs, Johns Hopkins University, 3400 N Charles Street, Baltimore, MD, 21211, United States of America, bhobbs@jhu.edu, Pearl Donohoo-Vallet

Transmission planning commonly follows a deterministic approach. This deterministically-derived plan is then tested for performance under various scenarios. This work instead explicitly plans transmission under uncertainty and includes multiple stages to allow for recourse decisions. We also model the interaction between new transmission and generation facilities by co-planning both transmission and generation simultaneously.

■ FB26

26- Forbes Room

Optimization in Big Data

Cluster: Stochastic Optimization

Invited Session

Chair: Diego Klabjan, Professor, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208, United States of America, d-klabjan@northwestern.edu

1 - Large-scale Optimization With Mapreduce and Spark

Alexandros Nathan, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208, United States of America, anathan@u.northwestern.edu, Diego Klabjan

In the age of Big Data, the need to train massive statistical models is ever-increasing. Parallel computing is arguably the most efficient way to train such models. In this work we compare three data-parallel and MapReduce-friendly optimization algorithms, namely the iterative parameter averaging method (IPA), the alternating direction method of multipliers (ADMM) and the progressive hedging method (PH). We conduct numerical experiments in MapReduce and Spark on problems that arise in machine learning, and we study the trade-offs between time and solution quality.

2 - A Method for Solving the Stochastic Fleet Assignment Problem using MapReduce and Parallelization

Mingyang Di, Northwestern University, 2145 Sheridan Road, C210, Evanston, IL, 60208, United States of America, mingyangdi2012@u.northwestern.edu, Diego Klabjan

We propose a two-stage stochastic fleet assignment model (FAM) and solve the model through a noble MapReduce-based progressive hedging approach. The developed algorithm could dramatically reduce the overall running time, thus bringing the model even closer to a point of integration into a practice-oriented support system.

3 - Mining Of Disease Trends And Treatment Outcome

Eva Lee, Georgia Institute of Technology, eva.lee@isye.gatech.edu

This work is joint with Care Coordination Institute in South Caroline. We will discuss the use of 2.7 million patient data from over 400+ providers for studying disease trends and treatment outcome. In this talk, we will focus on chronic disease management and practice variance and outcome prediction across the multiple practices. Optimization and machine learning advances will be discussed.

■ FB27

27- Duquesne Room

The Geometry of Linear Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Jesus De Loera, Professor, University of California, Dept. of Mathematics, Davis, CA, 95616, United States of America, deloera@math.ucdavis.edu

1 - Special Polynomial Cases of Colorful Linear Programming

Frédéric Meunier, Professor, Ecole des Ponts ParisTech, 6 et 8, av. Blaise Pascal, Marne-la-Vallèe, 77455, France, frederic.meunier@enpc.fr, Wolfgang Mulzer, Pauline Sarrabezolles, Yannik Stein

Consider a linear program with pairwise disjoint feasible bases B_1,...,B_r. There exists a feasible basis B whose intersections with the B_i's have sizes of arbitrary ratios (colorful CarathÈodory theorem). Whether such a basis B can be computed in polynomial time is an open question. We present polynomial cases, e.g. the case when r=2 or cases provided by applications of the colorful CarathÈodory theorem to graph theory, and show that they become NP-complete as soon as feasibility of the B_i's is no longer required.

2 - Diameters of Polyhedra and Simplicial Complexes

Francisco Santos, Professor, University of Cantabria, Santander, Spain, francisco.santos@unican.es

The Hirsch conjecture stated that graphs of d-polyhedra with n facets have diameter at most n-d. Although it has been disproved (Klee-Walkup 1967, Santos 2012), no polynomial upper bound is known for the diameters that were conjectured linear and no polyhedron violating the bound by more than 25% is known. In this talk we review recent approaches to the question, some in the world of polyhedra and some generalizing it to simplicial complexes. In particular, we show that the maximum diameter of pure simplicial complexes is in the order of n^d, we sketch the proof of Hirsch's bound for flag polyhedra by Adiprasito and Benedetti, and we summarize the ideas in the polymath 3 project, a collective effort trying to prove an upper bound of nd.

3 - Covering Grid Points with Subspaces

Tamon Stephen, Simon Fraser University, Department of Mathematics, 250-13450 102nd Ave., Surrey, BC, V3T 0A3, Canada, tamon@sfu.ca

We consider a problem of covering (perhaps modulo 2) a box of grid points with axis-aligned affine subspaces. The objective is to do this so that each co-ordinate hyperplane containing grid points contains a subspace from the cover, and to minimize the number of elements in the cover. This problem arises in connection with the colourful simplicial depth problem.

■ FB28

28- Liberty Room

Combinatorial Optimization in Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Erick Moreno-Centeno, Texas A&M University, 3131 TAMU, College Station, TX, United States of America, emc@tamu.edu

1 - Optimal Design of Switched Ethernet Networks Implementing the Multiple Spanning Tree Protocol

Martim Joyce-Moniz, Université Libre de Bruxelles - Graphes et Optimisation Mathématique, Boulevard du Triomphe CP 210/01, Bruxelles, 1050, Belgium, martim.moniz@ulb.ac.be, Bernard Fortz, Luis Neves Gouveia

We propose and compare different MIP formulations to the Traffic Engineering problem of finding optimal designs for switched Ethernet networks implementing the IEEE Multiple Spanning Tree Protocol. This problem consists in designing networks with multiple VLANs, such that each one is defined by a spanning tree that meets the required traffic demand. Additionally, all the VLANs must jointly verify the bandwidth capacity of the network. Meanwhile the worst-case link utilization (ratio between link's load and capacity) is minimized. Moreover, we propose a binary search algorithm, that produces near-optimal solutions, by solving a sequence of sub-problems, that can be seen as a capacitated, multiple spanning tree versions of the OCSTP (Hu,74).

2 - Network Simplex Applied to the Harder Minimal Steiner Tree Problem

Badri Toppur, Associate Professor, Rajalakshmi School of Business, Kuthambakkam Post, Chennai, India, badri.toppur@rsb.edu.in

We have described a scheme for a divide-and-conquer heuristic for the minimal Steiner tree problem in the Euclidean plane and in space. Inserting the best bridge between two optimal Steiner trees often does not give the best topology for the combined tree. The topology selection sub-problem can be solved by the application of network simplex. This is achieved by placing unit demands on the nodes of one sub-tree, and unit supplies on the nodes of the other sub-tree. The network simplex is performed, on the complete graph of the two sub-trees. One can repeat iterations of the network simplex, and the algorithm for optimizing a fixed topology, until there is no change in the topology and no change in the coordinates of the Steiner points.

■ FB29

29- Commonwealth 1

New Developments on QCQPs and MINLPs I

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Daniel Bienstock, 500 W 120th St, New York, NY, 10027, United States of America, dano@columbia.edu

1 - Computational Approaches to Mixed Integer Second Order Cone Optimization (MISOCO)

Aykut Bulut, PhD Candidate, Lehigh University, 200 W Packer Avenue, Bethlehem, PA, 18015, United States of America, aykut@lehigh.edu, Ted Ralphs

It is well-known that the feasible region of a MISOCO problem can be approximated by a polyhedron. We present a solver implementing a cutting plane algorithm for solving second order conic optimization (SOCO) problems based on such linear approximations. In this algorithm, we iteratively solve linear optimization problem (LP) relaxations of the original MISOCO problem, strengthened by generating linear cuts from the conic constraints. We discuss computational performance of this approach on conic benchmark library (CBLIB 2014) problems.

2 - Max Clique Cuts for Standard Quadratic Programs

Jonas Schweiger, CPLEX Optimization, IBM Italy, Via Martin Luther King 38/2, Bologna, BO, 40132, Italy, jonas.schweiger@it.ibm.com, Pierre Bonami, Andrea Tramontani, Andrea Lodi

The theorem of Motzkin-Strauss establishes a connection between the clique number of a graph and a Standard Quadratic Program (SQP), i.e. the optimization of a quadratic objective over the standard simplex. We use this result to derive cutting planes on the linearization variables of SQPs and provide computational results to show the efficiency. The cuts can be generalized for QCQP and also to quadratic problems with a weighted upper bound on the original variables.

3 - Zero-Half Cuts for Solving Nonconvex Quadratic Programs with Box Constraints

Jeff Linderoth, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53711, United States of America, linderoth@wisc.edu, Oktay Gunluk, Pierre Bonami

Inequalities valid for the Boolean Quadric Polytope are also valid for nonconvex quadratic programs with box constraints. We demonstrate the utility of using zero-half Chvatal Gomory cuts in a solver for nonconvex quadratic programs.

■ FB30

30- Commonwealth 2

Approximation and Online Algorithms XIII

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Bruce Shepherd, Prof, McGill University, 805 Sherbrooke St West, Montreal, QC, H3A2K6, Canada, bruce.shepherd@mcgill.ca

1 - Excluded Grid Theorem: Improved and Simplified

Julia Chuzhoy, Toyota Technological Institute at Chicago, 6045 S. Kenwood Ave, Chicago, Il, 60637, United States of America, cjulia@ttic.edu, Chandra Chekuri

One of the key results in Robertson and Seymour's seminal work on graph minors is the Excluded Grid Theorem. The theorem states that for every fixed-size grid H, every graph whose treewidth is large enough, contains H as a minor. This theorem has found many applications in graph theory and algorithms. Let f(k) denote the largest value, such that every graph of treewidth k contains a grid minor of size f(k). Until recently, the best known bound on f(k) was sub-logarithmic in k. In this talk we will survey new results and techniques that establish polynomial bounds on f(k).

2 - Approximation Algorithms for All-or-Nothing Flow and Disjoint Paths

Chandra Chekuri, Professor, University of Illinois, 201 N. Goodwin Ave, Urbana, IL, 61801, United States of America, chekuri@illinois.edu

Given an undirected graph G and k source-sink pairs we consider the problem of maximizing the number of pairs that can be routed. A set of pairs S is routable if there is a feasible multiflow in G that routes one unit of flow for each pair in S. If the flow is allowed to be fractional we have the all-or-nothing flow problem. If the flow is required to be integral we obtain the disjoint paths problem. In this talk we will report on some recent work with Julia Chuzhoy that addresses the node-capacitated setting. In particular, we obtain a poly-logarithmic approximation for the all-or-nothing flow problem that guarantees a half-integral flow for the routed pairs.

3 - Capacitated Confluent Flows

Bruce Shepherd, Professor, McGill University, 805 Sherbrooke St West, Montreal, QC, H3A2K6, Canada, bruce.shepherd@mcgill.ca, Adrian Vetta

The single-sink confluent flow problem has a factor-3 approximation to the maximum throughput objective in the uniform node capacity setting. We discuss several roadblocks to extending this result to the case where nodes have general capacities. For the maximum single-sink capacitated confluent flow problem (directed or undirected), we show a poly-logarithmic hardness result in the case where capacities satisfy the no-bottleneck-assumption (NBA), and polynomial hardness for general instances. This former result stands in contrast to single-sink unsplittable flows which admit O(1) approximations in the NBA setting.

Friday, 1:10pm - 2:40pm

■ FC01

01- Grand 1

Complementarity/Variational Inequality VIII

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Stephen M. Robinson, University of Wisconsin - Madison, WI, smrobins@wisc.edu

1 - The Equilibrium Structure of Complementarity Problems

Shu Lu, Assistant Professor, University of North Carolina at Chapel Hill, 355 Hanes Hall, Cb#3260, UNC-Chapel Hill, Chapel Hill, NC, 27599, United States of America, shulu@email.unc.edu

We treat complementarity problems as Nash equilibrium problems by considering each component as a player. From such a viewpoint we analyze the structure of complementarity problems with a focus on properties such as solution existence and uniqueness.

2 - A Game-Theoretic Approach to Computation Offloading in Mobile Cloud Computing

Francisco Facchinei, University of Rome La Sapienza, Via Ariosto 25, Rome, 00185, Italy, facchinei@diag.uniroma1.it, Valeria Cardellini, Vittoria De Nitto Persone, Vincenzo Grassi, Francesco Lo Presti, Veronica Piccialli, Valerio Di Valerio

We consider a three-tier architecture for mobile and pervasive computing scenarios, consisting of a local tier of mobile nodes, a middle tier (cloudlets) of nearby computing nodes characterized by a limited amount of resources, and a remote tier of distant cloud servers, with practically infinite resources. We consider a usage scenario with no central authority and where mobile users behave non cooperatively. We define a model to capture the users behavior and formulate the problem as a generalized Nash equilibrium problem and show existence of an equilibrium. We present a distributed algorithm for the computation of an equilibrium and illustrate its behavior and the characteristics of the achieved equilibria.

3 - Linear Algebra and Affine Variational Inequalities

Stephen M. Robinson, University of Wisconsin - Madison, WI, smrobins@wisc.edu

Key portions of linear algebra deal with linear transformations of vector spaces, whereas key portions of the theory of affine variational inequalities (AVI) deal with linear transformations of more complex structures: the graphs of normal-cone operators of polyhedral convex sets. In this talk we will examine some of the similarities between these and discuss how they can help Students to understand the structure and behavior of AVI.

■ FC02

02- Grand 2

Optimization Problems with Moments and Polynomials II

Cluster: Conic Programming

Invited Session

Chair: Jiawang Nie, Associate Professor, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA, 92093, United States of America, njw@math.ucsd.edu

Co-Chair: Jean Lasserre, Laboratory for Analysis and Architecture of Systems, lasserre@laas.fr

1 - First-Order Methods for General Hyperbolic Programming

James Renegar, Cornell University, Rhodes Hall, Ithaca, NY, United States of America, renegar@cornell.edu

We show any hyperbolic program can easily be recast as a convex optimization problem in which the only constraints are linear equations, and the objective function is Lipschitz continuous with constant 1. Consequently, virtually any subgradient method can be applied to solving the recast problem. When a particular well-known subgradient method is employed, we show the number of iterations is (almost) optimal. Furthermore, we show the objective function is naturally smoothed, allowing accelerated gradient methods to be employed, resulting in the desired iteration counts for solving general hyperbolic programs, including all forms of linear programs, second-order cone programs and semidefinite programs.

2 - Matrix Relaxation of the LMI Domination Problem and Bounding its Error

J. William Helton, UC San Diego, Gillman Dr, La Jolla, CA, United States of America, helton@math.ucsd.edu

While determining if all solutions to a given LMI are solutions to another given LMI is an NP hard problem, a natural relaxation of this is to use matrix variables in the LMIs, thereby obtaining a relaxed problem which can be solved with an LMI. The talk describes a systematic approach to bounding the error of such relaxations. For the classic cube inclusion problem we obtain explicitly the (sharp) bound andnew probability results. With Igor Klep, Scott McCullough.

3 - Deciding Convexity of Symmetric Polynomials and Positivity of Multisymmetric Polynomials

Cordian Riener, cordian.riener@gmail.com, Paul Goerlach, Tillmann Weisser

The question how to certify non-negativity of a polynomial function lies at the foundation of polynomial optimisation. We present results of this question in the context of multisymmetric polynomials. In this setting we generalise a characterisation of non-negative symmetric polynomials. As a direct corollary result we are able to derive that in the case of (multi-)symmetric polynomials of a fixed degree testing for convexity can be done in a time which is polynomial in the number of variables. This is in sharp contrast to the general case, where it is known that testing for convexity is NP-hard already in the case of quartic polynomials.

■ FC03

03- Grand 3

Extended Formulations

Cluster: Combinatorial Optimization

Invited Session

Chair: Thomas Rothvoss, University of Washington, Seattle, WA, United States of America, rothvoss@uw.edu

1 - Subgraph Polytopes, Spanning Tree Polytopes and Independence Polytopes of Count Matroids

Stefan Weltge, Otto von Guericke University Magdeburg, weltge@ovgu.de, Volker Kaibel, Matthias Walter, Michele Conforti

Given a graph, we study the non-empty subgraph polytope, which is the convex hull of incidence vectors of pairs (F,S) where S is a non-empty subset of nodes and F is a set of edges with both endnodes in S. We show that the non-empty subgraph polytope and the spanning tree polytope have roughly the same extension complexity, and on the way give a complete linear description of the former. We further show how the non-empty subgraph polytope can be used to obtain polynomial size extended formulations for independence polytopes of count matroids, generalizing results by Iwata et al. on sparsity matroids. As a consequence, the extension complexities of these polytopes yield lower bounds on the extension complexity of the spanning tree polytope.

2 - Inapproximability of Combinatorial Problems via Small LPs and SDPs

Sebastian Pokutta, Georgia Institute of Technology, Ferst Dr., Atlanta, GA, United States of America, sebastian.pokutta@me.com, Gabor Braun, Daniel Zink

We provide a framework for studying the size of LPs and SDPs of combinatorial optimization problems without encoding them first as linear programs or semidefinite programs. As a result we can define the first consistent reduction mechanism that degrades approximation factors in a controlled fashion and which, at the same time, is compatible with approximate linear and semidefinite programming formulations. As a consequence we can establish strong linear programming inapproximability for LPs (and SDPs) with a polynomial number of constraints for a host of problems. Combining our framework with a recent result of Lee, Raghavendra, and Steurer we can also obtain inapproximability results for SDPs.

3 - No Small Linear Program Approximates Vertex Cover within a Factor 2 – epsilon

Abbas Bazzi, PhD Student, EPFL, Building INJ (INJ110), Station 14, Lausanne, 1015, Switzerland, abbas.bazzi@epfl.ch, Sebastian Pokutta, Samuel Fiorini, Ola Svensson

The vertex cover problem is one of the most important and intensively studied combinatorial optimization problems. Khot and Regev proved that the problem is NP-hard to approximate within a factor 2-epsilon, assuming the Unique Games Conjecture (UGC). Without resorting to the UGC, the best inapproximability result for the problem is due to Dinur and Safra: vertex cover is NP-hard to approximate within a factor 1.3606. We prove that every LP relaxation that approximates vertex cover within a factor of 2-epsilon has super-polynomially many inequalities. As a direct consequence of our methods, we also establish that LP relaxations that approximate the independent set problem within any constant factor have super-polynomially many inequalities.

■ FC04

04- Grand 4

Multi-Objective Optimization in Industry

Cluster: Multi-Objective Optimization

Invited Session

Chair: Nelson HeinProf., Universidade Regional de Blumenau, Rua Antonio da Veiga, 140, Blumenau, SC, 89012-900, Brazil, hein@furb.br

1 - Vector Games to Accounting Evaluation of Brazilian Companies by using Financial Indicators

Adriana Kroenke, Prof., Universidade Regional de Blumenau, Rua Antonio da Veiga, 140, Blumenau, SC, 89012-900, Brazil, akroenke@furb.br, Nelson Hein, Volmir Eugẽnio Wilhelm

The investor aims at strategically organizing their alternatives, which are read as being companies in which to invest or to be evaluated. Nature is composed by economic and financial ratios. From these indicators it was possible to establish the accounting positioning within its sector, taken here as being their competitors. The general objective was to evaluate the accounting positioning of steel and metallurgy companies listed on the BM&FBovespa by using Vector Games.

2 - VIKOR Method to Input Purchase in Brazilian Textile Industry

Nelson Hein, Prof., Universidade Regional de Blumenau, Rua Antonio da Veiga, 140, Blumenau, SC, 89012-900, Brazil, hein@furb.br, Leandro Keunecke, Adriana Kroenke

Technical specifications, delivery time and price are criteria involved in the analysis of inputs purchase in an organization. This research applied the Vikor method as a tool to support multi-criteria decision when purchasing inputs in a Brazilian textile company, in order to better meet quality and price parameters. The study considered the stable and unstable relativity of information in determining the weights of the criteria, obtained by entropy.

3 - A New Exact Method and Matheuristics for Bi-Objective 0/1 ILPs: Application to FTTx-Network Design

Markus Sinnl, ISOR, University of Vienna, Oskar-Morgenstern-Platz 1, Vienna, 1090, Austria, markus.sinnl@univie.ac.at, Ivana Ljubic, Markus Leitner, Axel Werner

We introduce a new exact iterative method and matheuristics for bi-objective 0/1 ILPs. The new exact method, adaptive search in objective space, is a combination of the epsilon-constraint method and the binary search in objective space. The matheuristics are boundary induced neighborhood search and directional local branching. Computational experiments are performed on real-world instances from telecommunication network design, which proved to be very difficult for traditional approaches.

■ FC05

05- Kings Garden 1

Stochastic Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Shiqian Ma, Assistant Professor, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, William M.W.Mong Engineering Building, Shatin, N.T., Hong Kong - PRC, sqma@se.cuhk.edu.hk

1 - A Gradient Aggregation Method for Large-Scale Learning

Jorge Nocedal, Northwestern University, Room M326, Technological Institute, 2145 Sheridan Road, Evanston, IL, United States of America, j-nocedal@northwestern.edu

We present a variance reduction (or gradient aggregation) method for very large machine learning problems where one pass over the data suffices to give good testing error. We describe the convergence properties of the algorithm and present numerical results on problems arising in machine learning.

2 - Convergence of Stochastic Quasi-Newton Methods

Alejandro Ribeiro, University of Pennsylvania, 200 South 33rd Street, Philadelphia, PA, 19104, United States of America, aribeiro@seas.upenn.edu, Aryan Mokhtari

The solution of stochastic optimization problems with stochastic gradient descent algorithms (SGD) is widespread, but SGD methods are slow to converge. This has motivated the use of stochastic quasi-Newton methods that utilize stochastic gradients as both, descent directions and ingredients of a curvature estimation methodology. This paper considers two methods: (i) RES, a regularized stochastic version of the BFGS method (ii) oLBFGS a stochastic limited memory version of BFGS. We show that both of these methods converge to optimal arguments under hypotheses of strong convexity and decreasing stepsizes. We further establish $O(1/t)$ convergence rates in expectation and present numerical evaluations to showcase the advantages relative to SGD.

3 - Stochastic Quasi-Newton Methods for Nonconvex Stochastic Optimization

Xiao Wang, University of Chinese Academy of Sciences, No. 19A, Yuquan Road, Beijing, China, wangxiao@ucas.ac.cn, Wei Liu, Shiqian Ma

We study stochastic quasi-Newton methods for nonconvex stochastic optimization. We assume that only stochastic gradient is available. Firstly, we propose a framework of stochastic quasi-Newton methods which extend classic methods working in deterministic settings to stochastic settings, and prove the almost sure convergence. Secondly, we propose a framework for a class of randomized stochastic quasi-Newton methods, where the iteration number is random. The complexity of such methods is analyzed. Thirdly, we present two specific methods that fall into this framework, namely stochastic damped-BFGS method and stochastic cyclic Barzilai-Borwein method. Finally, we report numerical results to demonstrate the efficiency of the proposed methods.

■ FC06

06- Kings Garden 2

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Aleksandr Kazachkov, PhD Student, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, akazachk@cmu.edu

1 - Applications of Bilevel Programming to Cutting Plane Generation

Stefano Coniglio, PhD, RWTH Aachen University, Lehrstuhl 2 für Mathematik, Pontdriesch 14-16, Aachen, 52062, Germany, coniglio@math2.rwth-aachen.de, Stefano Gualandi, Martin Tieves

We address the generation of “template-free” inequalities which, except for their validity, do not have a predetermined combinatorial structure. After highlighting the bilevel nature of their separation problem, we illustrate ways to tackle it, with an application to the separation of rank inequalities for the stable set problem. We then consider the problem of generating k cuts which jointly maximize the bound improvement. We show how to turn the corresponding bilevel generation problem into a single level one, with an application to the generation of stable set inequalities for the max clique problem and of cover inequalities for the 0-1 knapsack problem.

2 - Partial Hyperplane Activation for Generalized Intersection Cuts

Aleksandr Kazachkov, PhD Student, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, akazachk@cmu.edu, Egon Balas, Francois Margot, Selvaprabu Nadarajah

Generalized intersection cuts offer a non-recursive paradigm for cut generation in mixed-integer linear programs using a linear program formulated from a set of intersection points. The existing method to generate intersection points requires repeatedly intersecting (activating) hyperplanes with a polyhedron, which may create exponentially many points. We introduce and numerically evaluate a partial hyperplane activation procedure that yields a polynomial-sized point collection in polynomial time. We also characterize theoretical properties of these collections.

3 - A Multi-Level Approach to Semidefinite Integer Programs on Graphs

Fu Lin, Postdoctoral Appointee, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL, 60439, United States of America, fulin@mcs.anl.gov, Zichao Di, Sven Leyffer

Semidefinite programs with integer variables subject to linear constraints arise in many engineering applications. Modern applications involving large graphs are beyond the capability of existing SDP-based branch-and-bound solvers. We consider a multi-level approach that solves a sequence of coarsened problems on smaller graphs. With a careful design of interpolation schemes, we show that coarse-level solutions are guaranteed to be feasible for the fine-level problems. This feature enables a multi-level branch-and-bound framework for semidefinite integer programs.

■ FC07

07- Kings Garden 3

PDE-Constrained Imaging and Shape Optimization

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Mazlinda Ibrahim, University of Liverpool, 608,, Monument Buildings, Liverpool, L3 5PH, United Kingdom, mazlinda@liv.ac.uk

1 - Shape Optimization of the Boussinesq Equations via a Characteristics P1/P1 FE Discretization

Michael Fischer, TU Darmstadt, Dolivostrasse 15, Darmstadt, Germany, mfischer@mathematik.tu-darmstadt.de, Stefan Ulbrich

In this talk we consider the perturbation of identity method for shape optimization based on the works of Murat and Simon, to solve shape optimization problems governed by the Boussinesq equations. After an introduction to the control problem on PDE level we introduce the stabilized characteristics P1/P1 finite element method as a discretization concept for the Boussinesq equations. Furthermore, we investigate the sensitivity of the discrete operator describing the stabilized characteristics FE method with respect to the control and state variables in a suitable function space setting.

2 - Multigrid-Base Optimization Approach for Tomographic Inversion from Multiple Data Modalities

Zichao Di, Postdoctoral Appointee, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL, 60439, United States of America, wendydi@mcs.anl.gov, Stefan Wild, Sven Leyffer

Fluorescence tomographic reconstruction can be used to reveal the internal elemental composition of a sample while transmission tomography can be used to obtain the spatial distribution of the absorption coefficient inside the sample. In this work, we integrate both modalities and formulate an optimization approach to simultaneously reconstruct the composition and absorption effect in the sample. By using multigrid¨-based optimization framework (MG/OPT), significant speedup and improvement of accuracy has shown for several examples.

3 - A Decomposition Model Combining Parametric and Non-Parametric Image Registration

Mazlinda Ibrahim, University of Liverpool, 608, Monument Buildings, Liverpool, L3 5PH, United Kingdom, mazlinda@liv.ac.uk, Ke Chen

Image registration aims to find a reasonable transformation so that the template image becomes similar to the so-called given reference image. Through such transformation, information from these images can be compared or combined. There exist many image registration models and the models can be divided into either parametric or non-parametric categories. In this talk, I shall introduce a novel image registration model called a decomposition model where it combines parametric and non-parametric models. We choose one cubic B-splines and a linear curvature model for parametric and non-parametric part respectively.

■ FC08

08- Kings Garden 4

Algebraic Methods in Conic Optimization

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Amir Ali Ahmadi, Princeton University, a_a_a@princeton.edu

1 - Generic Sensitivity Analysis for Semi-Algebraic Optimization

Adrian Lewis, Professor, Cornell University, School of ORIE, Ithaca, NY, 14853, United States of America, adrian.lewis@cornell.edu, Dmitriy Drusvyatskiy, Alexander Ioffe

Concrete optimization is often semi-algebraic, definable using only polynomial inequalities. The first-order optimality conditions involve a set-valued operator on n-dimensional space whose graph is everywhere n-dimensional (or “thin”). Semi-algebraic monotone operators also have thin graphs, by Minty’s theorem. A Sard-type theorem holds for semi-algebraic operators with thin graphs, ensuring good sensitivity behavior for generic data. In particular, optimizers of semi-algebraic problems typically lie on an “active manifold” (identified by popular algorithms), and satisfy strict complementarity and the second-order sufficient conditions.

2 - Fast Binary Embeddings

Constantine Caramanis, University of Texas-Austin, Austin, TX, United States of America, constantine@utexas.edu

Binary embedding is a nonlinear dimension reduction methodology where high dimensional data are embedded into the Hamming cube while preserving the structure of the original space. Specifically, for an arbitrary set of N distinct points on the p-dimensional sphere, our goal is to encode each point using m-dimensional binary strings such that we can reconstruct their geodesic distance up to δ-uniform distortion. Existing binary embedding algorithms either lack theoretical guarantees or suffer from running time $O(mp)$. We make three contributions: (1) we establish a lower bound that shows any binary embedding oblivious to the set of points requires $m = \Omega(\log{N}/\delta^2)$ bits and a similar lower bound for non-oblivious embeddings into Hamming distance; (2) we propose a novel fast binary embedding algorithm with provably optimal bit complexity m = O(\log{N}/\delta^2}) and near linear running time O(p \log p) whenever $\log N \ll \delta \sqrt{p}$, with a slightly worse running time for larger \log N; (3) we also provide an analytic result about embedding a general set of points on the sphere, with even infinite size. Our theoretical findings are supported through experiments on both synthetic and real data sets.

3 - Relative Entropy Relaxations for Signomial Optimization

Venkat Chandrasekaran, Caltech, 1200 E. California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, venkatc@caltech.edu, Parikshit Shah

Due to its favorable analytical properties, the relative entropy function plays a prominent role in a variety of contexts in information theory and in statistics. In this talk, we discuss some of the beneficial computational properties of this function by describing a class of relative-entropy-based convex relaxations for obtaining bounds on signomials programs (SPs), which arise commonly in many problems domains. SPs are non-convex in general, and families of NP-hard problems can be reduced to SPs. The central idea underlying our approach is a connection between the relative entropy function and efficient proofs of nonnegativity via the arithmetic-geometric-mean inequality.

■ FC09

09- Kings Garden 5

Alternating Methods and Generalized Proximal Point Algorithms

Cluster: Nonsmooth Optimization

Invited Session

Chair: Maryam Yashtini, Dr., Georgia Institute of Technology, School of Mathematics, Atlanta, GA, 30332, United States of America, myashtini3@math.gatech.edu

1 - Iteration Complexity Analysis of Block Coordinate Descent Methods

Xiangfeng Wang, Dr., East China Normal University, 3663# North Zhongshan Road, Science Building A1614, Shanghai, China, xfwang.nju@gmail.com, Mingyi Hong, Zhi-Quan Luo, Meisam Razaviyayn

We provide a unified iteration complexity analysis for a family of general block coordinate descent (BCD) methods, covering popular methods such as the block coordinate gradient descent (BCGD) and the block coordinate proximal gradient(BCPG), under various different coordinate update rules. Moreover, we show that for a special class of algorithm called the block coordinate minimization (BCM) where each block is minimized exactly, the sublinear rate can be achieved either when certain per-block strong convexity assumption is met, or when the smooth function satisfies some additional assumptions.

2 - On the Linear Convergence Rate of a Generalized Proximal Point Algorithm

Min Tao, Dr., Nanjing University, HanKou Road No. 22, Nanjing, China, taom@nju.edu.cn, Xiaoming Yuan

The proximal point algorithm (PPA) has been well studied in the literature. Its linear convergence rate has been studied by Rockafellar in 1976 under certain condition. We consider a generalized PPA in the generic setting of finding a zero point of a maximal monotone operator, and show that the condition proposed by Rockafellar can also sufficiently ensure the linear convergence rate for this generalized PPA. Both the exact and inexact versions of this generalized PPA are discussed.

3 - Fast Alternating Minimization Algorithms for Convex and Nonconvex Inverse Problems and Applications

Maryam Yashtini, Dr., Georgia Institute of Technology, School of Mathematics, Atlanta, GA, 30332, United States of America, myashtini3@math.gatech.edu

In the first part, I will introduce a fast alternating direction approximate Newton method for solving total variation regularized inverse problems. The proposed algorithm is designed to handle applications where the matrix in the fidelity term is a large dense, ill conditioned. Numerical results are provided using test problems from parallel magnetic resonance imaging. In the second part, I will focus on the Euler's Elastica-based model. The associated Euler-Lagrange equation of this model is fourth order hence minimization of energy functionals becomes very complex. I will introduce some algorithms to solve this problem much more efficiently. Comparisons are made with some state of art algorithms on image inpainting and denoising.

■ FC10

10- Kings Terrace

Semidefinite Programming and Portfolio Management

Cluster: Finance and Economics

Invited Session

Chair: Koichi Fujii, NTT DATA Mathematical Systems Inc., 1F Shinanomachi Rengakan, 35, Shinanomac, Shinjuku-ku, Tokyo 160-0016, JAPAN, Tokyo, Japan, fujii_kouichi@msi.co.jp

1 - Two SDP-Based Algorithms for the Long-Short Portfolios

Koichi Fujii, NTT DATA Mathematical Systems Inc., 1F Shinanomachi Rengakan, 35, Shinanomac, Shinjuku-ku, Tokyo 160-0016, JAPAN, Tokyo, Japan, fujii_kouichi@msi.co.jp, Kouhei Harada, Takahito Tanabe

We present two SDP-based algorithms for the optimal long-short portfolios, which are known to be difficult MIQPs. One is a modified Lagrangian relaxation in which we impose semidefinite constraints on Lagrangian dual problems. The other is a randomized algorithm which utilizes SDP relaxations in the same way as Goemans-Williamson MAX CUT approximation algorithm. Computational results show the significant improvements in proving the optimality or finding good feasible solutions compared with LP-based branch-and-bound algorithm.

■ FC11

11- Brigade

Process Flexibility Network Design

Cluster: Combinatorial Optimization

Invited Session

Chair: Vineet Goyal, Columbia University, 500W 120th St, New York, NY, United States of America, vgoyal@ieor.columbia.edu

1 - Optimal Sparse Designs for Process Flexibility via Probabilistic Expanders

Yuan Zhou, MIT, Department of Mathematics, MIT, Cambridge, MA, 02140, United States of America, yuanzhou@mit.edu, Jiawei Zhang, Xi Chen

We study the problem of how to design a sparse flexible process structure in a balanced and symmetrical production system to match supply with random demand more effectively. Our goal is to provide a sparsest design to achieve (1-e)-optimality relative to the fully flexible system. In a system with n plants and n products, Chou et al. proved that there exists a graph expander with O(n/e) arcs to achieve (1-e)-optimality for every demand realization. In this paper, we introduce a new concept called probabilistic graph expanders. We prove that a probabilistic expander with O(n ln(1/e)) arcs guarantees (1-e)-optimality with high probability (w.h.p.). We also show any structure needs O(n ln(1/e)) arcs to achieve (1-e)-optimality w.h.p.

2 - Distribution-Free Analyses of Process Flexibility Design

Tianhu Deng, Assistant Professor, Tsinghua University, Shunde Building 607, Tsinghua University, Beijing, 100084, China, deng13@mail.tsinghua.edu.cn, Max Zuojun Shen

For a process flexibility design model, we do not assume full knowledge of demand joint distribution and instead investigate four distribution-free models: (1) marginal moment model, (2) marginal distribution model, (3) cross moment model, and (4) marginal moment model with independence. For the first three models, we provide efficient solution methods based on second order cone programming, stochastic bounds and completely positive cone programming, respectively. For the fourth model, we show that three-point distributions are the worst-case discrete distributions.

3 - Sparse Process Flexibility Designs: Is Long Chain Really Optimal?

Antoine Desir, Columbia University, 601 W 113th Street, Apt 3J, New York, NY, 10025, United States of America, ad2918@columbia.edu, Jiawei Zhang, Yehua Wei, Vineet Goyal

Sparse process flexibility and long chain has become an important concept in design flexible manufacturing systems since the seminal paper of Jordan and Graves (1995). In this presentation, we study the performance of long chain in comparison to all designs with at most 2n edges over n supply and n demand nodes. We show that, surprisingly, long chain is not optimal in this class of networks even for i.i.d. demand distributions. This is quite surprising and contrary to the intuition that a connected design performs better than a disconnected one for symmetric distributions. We then show that the long chain is optimal if we compare it to connected designs with at most 2n edges for exchangeable demand distributions.

■ FC13

13- Rivers

Modeling Languages and Libraries in Optimization

Cluster: Constraint Programming

Invited Session

Chair: Laurent Michel, Associate Professor, University of Connecticut, 371 Fairfield Rd, Storrs, CT, 06269, United States of America, ldm@engr.uconn.edu

1 - Automated Modelling in Constraint Programming with Essence and Conjure

Ozgur Akgun, University of St Andrews, School of Computer Science, St Andrews, United Kingdom, ozgur.akgun@st-andrews.ac.uk

Constraint Programming (CP) offers an efficient means of solving a variety of combinatorial problems. A well-recognised bottleneck in the application of CP is the formulation of an effective (or even correct) CP model. This can lead to very poor solving efficiency or incorrect solutions. Our approach to this challenge is to allow users to describe problems in the specification language Essence without having to make low level modelling decisions. Then, our automated modelling tool Conjure automatically produces concrete CP models, including class-level symmetry breaking constraints. Since it is possible to generate several alternative models for a problem specification, Conjure uses heuristics and model racing to find an effective model.

2 - The Objective-CP Modeling and Optimization Platform

Laurent Michel, Associate Professor, University of Connecticut, 371 Fairfield Rd, Storrs, CT, 06269, United States of America, ldm@engr.uconn.edu, Pascal Van Hentenryck

Constraint Programming promotes an approach to combinatorial optimization that separates the declarative modeling of the problem from the creation of search procedures. This separation of concerns lends considerable flexibility and opens the door to an environment where a single high-level declarative model can be used with multiple solvers to produce technology specific programs as well as increasingly complex hybrid solvers. This talk investigates Objective-CP, an optimization platform that embraces this principle and delivers a compelling environment in which one can author complex optimization programs.

3 - An XML Schema for Matrix and Cone Programming

Horand Gassmann, Dalhousie University, Rowe School of Business, Halifax, NS, Canada, Horand.Gassmann@Dal.Ca, Imre Polik, Kipp Martin, Jun Ma

Cone programming and matrix programming are relatively new areas of mathematical optimization that have received attention in recent years due to their applicability in solving stochastic programs as well as mixed integer programs. Solver implementations exist, but benchmarking is hampered because there are few accepted input formats in which to communicate instances to the solvers. This talk presents efforts to facilitate the formulation of matrix and cone programming problems within the OSiL framework, a unified representation format for a large variety of mathematical optimization problem instances. OSiL is part of the OS project, an open source COIN-OR project. A prototype interface to the CSDP solver is also described.

■ FC14

14- Traders

Price of Anarchy II

Cluster: Game Theory

Invited Session

Chair: Vasilis Syrgkanis, Post-doc Researcher, 641 Avenue of the Americas, NY, United States of America, bsyrganis@gmail.com

1 - Efficiency, Pricing, and the Walrasian Mechanism

Brendan Lucier, Researcher, Microsoft Research, One Memorial Drive, Cambridge, MA, United States of America, brlucier@microsoft.com

Central results in economics guarantee efficient equilibria in markets, but a common assumption is that agents honestly report their demands. In practice agents can benefit by reducing demand, leading to inefficiency. But how inefficient can these outcomes be? We study the Walrasian Mechanism: collect reported demands, then find clearing prices in the reported market. We show that every equilibrium yields a constant fraction of the optimal welfare, in a variety of settings without complements. I will also discuss a related approach: post fixed prices based on distributions over preferences, leading to sequential price-taking behavior. This approach can be used to design simple, truthful mechanisms in Bayesian settings.

2 - Valuation Compressions in VCG-Based Combinatorial Auctions

Paul Duetting, London School of Economics, Houghton Street, London, WC2A 2AE, United Kingdom, P.D.Duetting@lse.ac.uk, Martin Starnberger, Monika Henzinger

The focus of classic mechanism design has been on truthful direct-revelation mechanisms. In the context of combinatorial auctions the truthful direct-revelation mechanism that maximizes social welfare is the VCG mechanism. For many valuation spaces computing the allocation and payments of the VCG mechanism, however, is a computationally hard problem. We prove upper and lower bounds on the welfare loss that results from restricting the bids to a subspace of the valuation space for which the VCG outcome can be computed efficiently. All our bounds apply to equilibrium concepts that can be computed in polynomial time as well as to learning outcomes. Our bounds show that the welfare loss increases with expressiveness.

3 - Price Competition in Online Markets

Renato Paes Leme, Researcher, Google Research, 111 8th Ave, New York, NY, 10011-5201, United States of America, renatoppl@google.com, Moshe Babaioff, Noam Nisan

We consider a single buyer with a combinatorial preference that would like to purchase related products and services from different vendors, where each vendor supplies exactly one product. We study the game that is induced on the vendors, where a vendor's strategy is the price that he asks for his product. This model generalizes both Bertrand competition and Nash bargaining and captures a wide variety of complex scenarios. We show existence of Nash equilibrium and give conditions for uniqueness. We also discuss the efficiency of equilibria.

■ FC15

15- Chartiers

Routing and Facility Location

Cluster: Combinatorial Optimization

Invited Session

Chair: Andreas Bley, Heinrich-Plett-Str. 40, Kassel, Germany, abley@mathematik.uni-kassel.de

1 - A Compact MIP for Aggregation and Multicast Trees under Flexible Routing and Function Placement

Matthias Rost, TU Berlin, Marchstrafle 23, MAR 4-4, Berlin, Germany, mrost@inet.tu-berlin.de, Stefan Schmid

With the advent of Software-Defined Networking and Network Functions Virtualization, the selective and flexible placement of functionality has recently gained importance. We introduce the Constrained Virtual Steiner Arboresence Problem that captures spanning multicast and aggregation trees where installing multicast (duplication of flows) or aggregation (merging of flows) functionality comes at a certain price and needs to be traded off with bandwidth usage costs. We discuss the relation to classic optimization problems and present our main result: a single-commodity flow Mixed-Integer Program that relies on a novel flow decomposition scheme. We also derive linear heuristics and show the benefits in a computational study.

2 - A Constant-Factor Local Search Approximation for Two-Stage Facility Location Problems

Felix J. L. Willamowski, Chair of Operations Research, RWTH Aachen, Kackertstrasse 7, Aachen, 52072, Germany, willamowski@or.rwth-aachen.de, Andreas Bley

We present a constant-factor local search approximation algorithm for the metric two-stage uncapacitated facility location problem and a variation of this, where the demands of the clients are served via trees. Additionally, we show that a general mutable metric does not allow constant approximation factors and that the introduced algorithm permits a more general mutable metric in contrast to previous algorithms, which only allow scenario-dependend inflation factors.

■ FC16

16- Sterlings 1

Stochastic Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Milena Brand„o, Federal University of Uberl,ndia, 20 Street, Tupa, Ituiutaba, 38304-402, Brazil, milena@pontal.ufu.br

1 - Coupled Bisection for Root Ordering

Stephen Pallone, Cornell University, 290 Rhodes Hall, Cornell University, Ithaca, NY, 14853, United States of America, snp32@cornell.edu, Peter Frazier, Shane Henderson

We consider the problem of solving multiple “coupled” root-finding problems at once, in that we can evaluate every function at the same point simultaneously. Using a dynamic programming formulation, we show that a sequential bisection algorithm is a close-to-optimal method for finding a ranking with respect to the zeros of these functions. We show the ranking can be found in linear time, prove an asymptotic approximation guarantee of 1.44, and conjecture that this policy is near-optimal.

2 - Semi-proximal Mirror Prox for Nonsmooth Composite Minimization

Niao He, Georgia Institute of Technology, 765 Ferst Drive, Atlanta, United States of America, nhe6@gatech.edu, Zaid Harchaoui

We introduce a new first-order algorithm to solve composite minimization with objective given by non-smooth convex loss and norm regularization terms. The proposed algorithm, called Semi-Proximal Mirror-Prox , leverages the Fenchel-type representation of one part of the objective while handling the other part of the objective via linear minimization over the domain. The algorithm stands in contrast with more classical proximal gradient algorithms with smoothing, which require the computation of proximal operators and can therefore be impractical for high-dimensional problems. The algorithm exhibits optimal complexity bounds and promising experimental performance in comparison to competing methods.

■ FC17

17- Sterlings 2

Optimization Problems in the Evolution of Cancer

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Kevin Leder, Assistant Professor, University of Minnesota, 111 Church St, Minneapolis, MN, 55455, lede0024@umn.edu

1 - Treatment of Chronic Myeloid Leukemia with Multiple Targeted Therapies

Qie He, Assistant Professor, University of Minnesota, 111 Church St, Minneapolis, MN, 55455, qhe@umn.edu, Kevin Leder, Jasmine Foo, Junfeng Zhu

In the past fifteen years several targeted therapies have been developed to treat Chronic Myeloid Leukemia (CML). These new drugs have greatly improved the prognosis of newly diagnosed patients. However, many patients eventually develop CML that is resistant to therapy. We develop a mathematical model for the evolution of normal cells and CML cells that are sensitive and resistant to the therapy, and derive the optimal combination of treatment strategies under a variety of toxicity constraints. This problem can be modeled as a mixed integer program with ODE constraints. We obtain good solutions of this model by solving an approximate mixed integer linear program, and compare our solution with the strategy used in common practices.

2 - Robust Optimization of Dose Schedules in Radiotherapy

Hamidreza Badri, Graduate Student, University of Minnesota, 111 Church St, Minneapolis, MN, 55455, United States of America, badri019@umn.edu, Kevin Leder

A major difficulty of choosing an optimal radiation schedule is the uncertainty of model parameters due to geometric and patient specific uncertainties. This paper proposes a method for determining the optimal fractionation schedule in the Linear Quadratic model with multiple normal tissue toxicity constraints in the presence of uncertainties with unknown and known underlying distributions. We proved that our problem can be solved efficiently via a decision variable transformation and then iterating standard optimization algorithms. We performed substantial numerical experiments for head-and-neck tumors with six normal tissue constraints to reveal the effects of parameter uncertainty on the structure of optimal schedules.

3 - Minimizing the Risk of Cancer: Tissue Architecture and Cellular Replication Limits

Ignacio Rodriguez-Brenes, Post-doctoral Scholar, University of California Irvine, 340 Rowland Hall, University of Irvine, Irvine, CA, 92697, United States of America, ignacio.rodriguezbrenes@uci.edu, Natalia Komarova, Dominik Wodarz

Normal somatic cells are capable of only a limited number of divisions, which limits cell proliferation and the onset of tumors. Cancer cells find ways to circumvent this obstacle, typically by expressing telomerase. Hence, it is important to understand how a tissue’s architecture affects the replicative capacity of a cell population. We discuss how several characteristics of cell lineages affect the replication capacity of dividing cells. We describe an optimal tissue architecture that minimizes the replication capacity of cells and thus the risk of cancer. Some of the features that define an optimal tissue architecture have been documented in various tissues, suggesting that they may have evolved as a cancer-protecting mechanism.

■ FC18

18- Sterlings 3

Numerical Methods for Structured Nonlinear Programs II

Cluster: Nonlinear Programming

Invited Session

Chair: Christian Kirches, Junior Research Group Leader, TU Braunschweig / Heidelberg University, Im Neuenheimer Feld 368, Heidelberg, 69120, Germany, christian.kirches@iwr.uni-heidelberg.de

1 - Augmented Lagrangian Based Algorithm for Distributed Optimal Control

Boris Houska, Shanghai Tech University, 319 Yueyang Road, Shanghai, China, borish@shanghaitech.edu.cn, Janick Frasch, Moritz Diehl

This talk is about distributed derivative based algorithms for solving optimization problems with separable and potentially non-convex objectives as well as coupled affine constraints, a structure that is present in optimal control problems with long horizons. We propose a parallelizable method that borrows concepts from the field of sequential quadratic programming and augmented Lagrangian algorithms. In contrast to existing decomposition methods, such as the alternating direction method of multipliers, the proposed algorithm is applicable to non-convex optimization problems and can achieve a superlinear convergence rate. We present applications from the field of optimal control.

2 - Distributed IPM for Robust Model Predictive Control

Jens Hübner, Leibniz Universitaet Hannover, Welfengarten 1, Hannover, 30167, Germany, huebner@ifam.uni-hannover.de, Martin Schmidt, Marc C. Steinbach

We address MPC for dynamic processes given by ODEs with stochastic disturbances. Explicit modeling of the disturbances leads to nonlinear MSPs that we treat by an IPM framework. We solve the huge-scale KKT systems with a structure-exploiting direct method incorporating problem-tailored inertia corrections that avoid re-factorizations of the entire KKT matrix. We use internal numerical differentiation to evaluate first-order derivatives of the ODE solutions and generate second-order derivatives by a structured quasi-Newton approach based on partially separable Lagrangians. The algorithm is completely distributed based on a depth-first distribution of the tree that causes few communication overhead. Numerical results will be presented.

3 - A Dual Newton Strategy for Convex QP in Model Predictive Control

Sebastian Sager, Prof. Dr., Otto-von-Guericke Universitaet Magdeburg, Universitaetsplatz 2, Magdeburg, 39106, Germany, sager@ovgu.de, Janick Frasch, Moritz Diehl

QPs that arise from dynamic optimization problems typically exhibit a very particular structure. We propose a dual Newton strategy that exploits the block-bandedness similarly to an interior-point method and features warmstarting capabilities of active-set methods. We give implementation details and a convergence proof. A numerical study based on the open-source implementation qpDUNES shows that the algorithm outperforms both well-established general purpose QP solvers as well as state-of-the-art tailored control QP solvers significantly on the considered benchmark problems.

■ FC19

19- Ft. Pitt

Derivative-Free and Simulation-Based Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: John Eason, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, jeason@andrew.cmu.edu

1 - Parameter Calibration of High Dimensional Computationally Expensive Multimodal Models

Yilun Wang, University of Electronic Science and Technology of China, No.2006, Xiyuan Ave, West Hi-Tech Zone, Chengdu, 611731, China, yw397@cornell.edu

We have been further extending our proposed framework called ``SOARS", i.e. Statistical and Optimization Analysis for parameter calibrating of computationally expensive prediction models, based on Response Surfaces. The extension aims to achieve better performance for high dimensional problems, i.e., the main difficulty is the ``high dimensionality and small evaluations". Our work is to develop new efficient adaptive learning (also called sample selection or optimal experimental design) for better sparse approximation of the underlying relatively high dimensional computationally expensive black box function. Numerical experiments show the outstanding performance of our extensions.

2 - Surrogate Management for Mixed-Integer Derivative-Free Optimization for Industrial Applications

Anne-Sophie Crélot, University of Namur, Rempart de la Vierge 8, Namur, 5000, Belgium, ascr@math.unamur.be, Charlotte Beauthier, Dominique Orban, Caroline Sainvitu, Annick Sartenaer

We propose a surrogate management framework (SMF) for NOMAD, an implementation of the mesh-adaptive direct-search method, in the context of costly black-box mixed-integer industrial problems and aerodynamic applications. The SMF builds upon tools from Minamo, the surrogate-assisted evolutionary algorithm developed at Cenaero. We compare several surrogate strategies for mixed-integer derivative-free optimization and formulate recommendations based on our experience.

3 - Trust Region Methods for Optimization with Reduced Models Embedded in Chemical Process Flowsheets

John Eason, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, jeason@andrew.cmu.edu, Lorenz Biegler

For advanced simulation models in chemical process optimization, we propose reduced-model trust region methods with desired convergence properties. In particular, we handle equality constraints that link complex simulation models in a flowsheet, which cause difficulties with established trust region methods with reduced models. Here we develop new filter-based trust region methods and compare against straightforward penalty function formulations. We also sketch convergence properties and demonstrate advantages of the filter-based approach on several chemical process applications.

■ FC20

20- Smithfield

Optimization Aspects of Energy Efficient Mobility

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Armin Fügenschuh, Helmut Schmidt University / University of the Federal Armed Forces Hamburg, Holstenhofweg 85, Hamburg, 22043, Germany, fuegenschuh@hsu-hh.de

1 - Integrated Freight Train Composition and Scheduling under Energy Efficiency Aspects

Frederik Fiand, Technical University Braunschweig, Pockelsstr. 14, Braunschweig, 38106, Germany, f.fiand@tu-braunschweig.de, Uwe Zimmermann

Given a set of shipment requests and predefined freight train schedules that allow some local time shifts, our goal is to find optimal transportation plans. Here it is the main objective to minimize the energy consumption under consideration of several business rules like demand satisfaction, capacity constraints and release and due dates. The requirements result in a highly complex large scale problem based on tremendous time expanded networks. We develop a solution approach that combines a tailor made preprocessing with large scale Mixed Integer Programming techniques and provide first promising results. The corresponding project "e-motion" is funded by the German Federal Ministry of Education and Research (BMBF).

2 - Integrating Peak Loads into Energy Sensitive Operational Train Timetabling

Anja Haehle, Chemnitz University of Technology, Reichenhainer Strasse 39, Chemnitz, 09126, Germany, anja.haehle@mathematik.tu-chemnitz.de, Christoph Helmberg

Given passenger and freight trains with time windows and prespecified routes in a coarsened track network, operational train timetabling asks for feasible schedules of these trains that observe the time windows as well as station capacities and headway times. We present a model and an algorithmic framework for including energy information in scheduling the trains. Considering — on top of total energy consumption — peak loads at an early stage in the planning process only make sense, if later perturbations in departure times do not render the results useless. We discuss robust variants to cope with such uncertainties. For first steps into this direction we present computational results on real world instances of Deutsche Bahn.

3 - The Route Planning Problem for Airplanes

Nam Dung Hoang, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, hoang@zib.de, Marco Blanco, Ralf Borndoerfer, Thomas Schlechte

The goal of the air traffic service route planning problem for airplanes is to compute a feasible minimum-cost 4D-trajectory between two airports in a network for an aircraft and its starting amount of fuel. The total cost is the sum of fuel cost, overflight cost, and possibly time cost. Weather forecasts, aircraft properties as well as security and operative constraints regulating air traffic have to be considered. From the mathematical perspective it is a shortest path problem with complex constraints and dynamic edge costs on a large graph. In this talk we present a discrete-continuous approach for the problem. Due to the requirement of real world aviation operations our algorithm need to deliver a good solution within a few minutes.

■ FC21

21-Birmingham

Stochastic Aspects of Energy Management II

Cluster: Optimization in Energy Systems

Invited Session

Chair: Wim van Ackooij, EDF R&D, 1 Avenue du Général de Gaulle, Clamart, 92141, France, wim.van.ackooij@gmail.com

1 - Hydrothermal Unit Commitment Subject to Uncertain Demand and Water Inflows

Erlon Finardi, UFSC, EEL - CTC - UFSC - Caixa Postal 476, Florianopolis, 88040-900, Brazil, erlon.finardi@ufsc.br, Murilo Reolon Scuzziato, Antonio Frangioni

We study stochastic Unit Commitment problems where uncertainty concerns water availability in reservoirs and demand (weather conditions), as in the highly hydro-dependent Brazilian system. We compare different decomposition schemes (space and scenario approaches) for these large-scale mixed-binary linear programming problem in terms of quality of produced lower bound, quality of the solutions provided by Lagrangian heuristics, and running time. Tuning of the algorithmic parameters of the employed nonsmooth optimization solver is also discussed.

2 - Scenario Decomposition of Stochastic Unit Commitment Problems

Tim Schulze, The University of Edinburgh, Mathematics, JCMB 5620, Peter Guthrie Tait Road, Edinburgh, EH9 3FD, United Kingdom, t.schulze-2@sms.ed.ac.uk, Kenneth McKinnon

In recent years the expansion of renewable energy supplies has triggered an increased interest in stochastic optimization models for generation unit commitment. Solving this problem directly is computationally intractable for large instances. In this talk we describe a stabilised scenario decomposition algorithm and report test results with a central scheduling model of the British power system. We evaluate stochastic vs. deterministic rolling horizon scheduling over a period of one year and discuss the added value of stochastic planning.

3 - Optimization of Booked Capacity in Gas Transport Networks using Nonlinear Probabilistic Constraints

Holger Heitsch, Dr., Weierstrass Institute, Mohrenstrasse 39, Berlin, 10117, Germany, holger.heitsch@wias-berlin.de, Rene Henrion

We present an approach to deal with booked capacity optimization of gas transport networks under uncertainty, where we make use of probabilistic constraints representing a major model of stochastic optimization. One approach for solving such models consists in applying nonlinear programming methods. Therefore, approximations for values and gradients of probability functions must be provided. We introduce a sampling scheme based on the spheric-radial decomposition of Gaussian random vectors to simultaneously compute both values and gradients of corresponding probability functions. A theoretical concept for simple gas networks including one single cycle and numerical experiences are presented that demonstrate the efficiency of our approach.

■ FC22

22- Heinz

Advances in Integer Programming X

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - Primal Cuts in the Integral Simplex using Decomposition

Samuel Rosat, GERAD Research Center, 3000, ch. de la Cote Sainte Catherine, Montréal, QC, H3T2A7, Canada, samuel.rosat@gerad.ca, François Soumis, Andrea Lodi, Issmail Elhallaoui

We propose a primal algorithm for the Set Partitioning Problem based on the Integral Simplex Using Decomposition of Zaghrouti et al. (2014). We present the algorithm in a pure primal form, and show that cutting planes can be transferred to the subproblem. We prove that these cutting planes always exist and that they are primal cuts. We propose efficient separation procedures for primal clique and odd-cycle cuts, and prove that their search space can be restricted to a small subset of the variables. Numerical results demonstrate the effectiveness of adding cutting planes to the algorithm; tests are performed on set partitioning problems from aircrew and bus-driver scheduling instances up to 1,600 constraints and 570,000 variables.

2 - Influence of the Normalization Constraint in the Integral Simplex using Decomposition

François Soumis, Polytechnique Montrèal, 3000, ch. de la Cote Sainte Catherine, Montreal, QC, Canada, Francois.Soumis@gerad.ca, Issmail Elhallaoui, Samuel Rosat, Driss Chakour

For the set partitioning problem, there exists a decreasing sequence of integer extreme points that leads to the optimum, such that each solution is adjacent to the previous one. Several algorithms aim to determine that sequence; one example is the integral simplex using decomposition (ISUD) of Zaghrouti et al. (2014). In ISUD, the next solution is often obtained by solving a linear program without using any branching strategy. We study the influence of the normalization-weight vector of this linear program on the integrality of the next solution. We propose new normalization constraints that encourage integral solutions. Numerical tests on scheduling instances (with up to 500,000 variables) demonstrate the potential of our approach.

3 - Column Generation Combining Three Stabilization Methods and Impact on Generalized Assignment

Ruslan Sadykov, Inria Bordeaux - Sud-Ouest, 200 avenue de la Vieille Tour, Talence, 33405, France, Ruslan.Sadykov@inria.fr, Artur Alves Pessoa, Eduardo Uchoa, François Vanderbeck

To accelerate convergence of column generation, we combine dual price smoothing, directional smoothing, and piecewise linear penalty functions. Our parameter self-adjusting scheme is a key ingredient, reducing parameters to just one constant that requires tuning. This combined stabilization scheme performs significantly better than the individual stabilizations on the GAP set covering formulation. Beyond 400 jobs, instances could not be solved with existing individually stabilized column generation approaches due to severe convergence issues. Our approach can tackle instances with up to 80 machines and 1600 jobs. Combining it with a diversified diving heuristic, we improve published primal bounds for all open literature instances.

■ FC23

23- Allegheny

Matching and Assignment

Cluster: Combinatorial Optimization

Invited Session

Chair: Konstantinos Kaparis, Lancaster Univeristy, Department of Management Science, Lancaster University, Lancaster, LA1 4YX, United Kingdom, K.Kaparis@lancaster.ac.uk

1 - Perfect f-Matchings and f-Factors in Hypergraphs

Isabel Beckenbach, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, beckenbach@zib.de, Ralf Borndörfer, Robert Scheidweiler

Conforti, Cornuéjols, Kapoor, and Vuökovic generalized Hall's condition for the existence of a perfect matching in a bipartite graph to balanced hypergraphs. We show how this result can be used to derive a condition for the existence of a perfect f-matching and an f-factor in a unimodular hypergraph. We discuss how these conditions generalize the known ones in bipartite graphs. Furthermore, we give a condition for the existence of a perfect f-matching in a uniform, balanced hypergraph.

2 - A Minimal Polyhedral Description of Stable b-matching

Pavlos Eirinakis, Athens University of Economics and Business, Department of Management Science & Techn, Patission 76, Athens, 10434, Greece, peir@aueb.gr, Dimitrios Magos, Ioannis Mourtos

The theory of matroid-kernel polyhedra provides a linear description of stable b-matching (MM). We revisit this description to establish the dimension, minimal equation system and facets of the MM polytope. This minimal representation is significantly sparser than the existing one and linear to the size of the problem. It carries over to stable admissions (SA), for which we also establish the facial correspondence of the linear description based on matroid-kernels to the one based on combs. Besides bringing a closure to the polyhedral study of MM and SA, these results are of practical importance in variants involving additional constraints, e.g., couples in residency schemes, where problem specific combinatorial algorithms become useless.

■ FC24

24- Benedum

New Developments on QCQPs and MINLPs II

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Daniel Bienstock, 500 W 120th St, New York, NY, 10027, United States of America, dano@columbia.edu

1 - Graph-Theoretic Convexification of Polynomial Optimization Problems: Theory and Applications

Javad Lavaei, Assistant Professor, Columbia University, New York, New York, United States of America, lavaei@ee.columbia.edu, Ramtin Madani, Somayeh Sojoudi, Abdulrahman Kalbat, Morteza Ashraphijuo

The objective of this talk is to find a near-global solution of an arbitrary real or complex polynomial optimization problem. Using a semidefinite programming (SDP) relaxation, we aim to address several problems: How does structure affect the complexity of an optimization problem? How does sparsity help? How to design a penalized convex relaxation to find a near-global solution whenever the customary SDP relaxation fails? How to design an efficient numerical algorithm to solve a large-scale conic optimization problem? Our approach relies on the notions of OS-vertex sequence and treewidth in graph theory, matrix completion, and low-rank optimization, among others.

2 - Extended Formulations for Quadratic Mixed Integer Programming

Juan Pablo Vielma, MIT, 100 Main Street, E62-561, Cambridge, MA, 02142, United States of America, jvielma@mit.edu

An extended formulation for Mixed Integer Programming (MIP) is a formulation that uses a number of auxiliary variables in addition to the original or natural variables of a MIP. Extended formulations for linear MIP have been extensively used to construct small, but strong formulations for a wide range of problems. In this talk we consider the use of extended formulations in quadratic MIP to improve the performance of LP-based branch-and-bound algorithms.

3 - Convexification Tools for Non-Convex Quadratic Programs

Fatma Kilinc-Karzan, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, fkilinc@andrew.cmu.edu, Nam Ho-Nguyen, Sam Burer

We study structured non-convex sets defined by the intersection of a second-order cone (SOC) representable constraint, a single homogeneous non-convex quadratic and an affine hyperplane. We derive simple, computable convex relaxations given by a new SOC representable constraint, and show that our relaxations precisely describe the corresponding convex hull under easy to check conditions. Our results imply that the classical trust region subproblem (TRS) can be solved by only relying on SOC optimization. We develop an efficient first-order method to solve the resulting SOC problems associated with TRS, and establish its rate of convergence. This method involves only matrix-vector products at each iteration and thus scales up very well.

■ FC25

25- Board Room

Optimization in Energy Systems II

Cluster: Optimization in Energy Systems

Invited Session

Chair: Victor Zavala, Computational Mathematician, Argonne National Laboratory, 9700 South Cass Ave, Argonne, IL, 60439, United States of America, vzavala@mcs.anl.gov

1 - A Data-Driven Bidding Model for a Cluster of Price-Responsive Consumers of Electricity

Juan Miguel Morales Gonzalez, Associate Professor, Technical University of Denmark, Matematiktorvet, Building 303b, 008, Kgs. Lyngby, 2800, Denmark, jmmgo@dtu.dk, Javier Saez-Gallego, Marco Zugno

We deal with the market bidding problem of a cluster of price-responsive consumers of electricity. We develop an inverse optimization method that uses price-consumption data to estimate the complex market bid that best captures the price-response of the cluster. A complex market bid is defined here as a series of utility functions plus some physical constraints on demand such as maximum pick-up and drop-off rates. The proposed modeling approach also leverages information on exogenous factors that may influence the consumption behavior of the cluster, such as outside temperature, calendar effects, etc. We test the proposed methodology for a particular application: forecasting the power consumption of a small aggregation of households.

2 - Moment-based Relaxations of the Optimal Power Flow Problem

Daniel Molzahn, Dow Postdoctoral Fellow, University of Michigan, 1301 Beal Avenue, Room 4234A, Ann Arbor, MI, 48109, United States of America, dan.molzahn@gmail.com, Ian Hiskens

Optimal power flow (OPF) is the key problem in operating electric power systems. A hierarchy of convex “moment” relaxations globally solves many non-convex OPF problems for which existing relaxations fail. Comparing the feasible spaces of the low-order relaxations illustrates the capabilities of the moment relaxations. Exploiting sparsity and selectively applying the higher-order relaxation enables global solution of larger problems.

3 - A Structure-Oriented Approach to Nonlinear Optimization of Energy Systems

Nai-Yuan Chiang, Argonne National Laboratory, 9700 South Cass Avenue, Lemont, IL, United States of America, nychiang@mcs.anl.gov, Cosmin Petra, Victor Zavala

We present a structure-oriented approach for nonlinear programs arising in power grid, buildings, and natural gas infrastructures. The approach can be used when inertia information is unavailable or unreliable and is thus suitable for tailored linear algebra implementations. We present a global convergence proof and numerical evidence that the approach is as robust as modern NLP packages and can tackle large stochastic programs.

■ FC27

27- Duquesne Room

Discrepancy Theory and its Applications

Cluster: Combinatorial Optimization

Invited Session

Chair: Daniel Dadush, CWI, Science Park, Amsterdam, Netherlands, dndadush@gmail.com

1 - Geometric Discrepancy and Packings

Esther Ezra, Assistant Professor, Georgia Tech, School of Mathematics, Georgia Tech, 686 Cherry Street, Atlanta, GA, 30332-0160, United States of America, esther@cims.nyu.edu

Discrepancy theory has been developed into a diverse and fascinating field, with numerous closely related areas. In this talk, I will survey several classic results in combinatorial and geometric discrepancy and then present discrepancy bounds for set systems of bounded ``primal shatter dimension”, with the property that these bounds are sensitive to the actual set sizes. These bounds are nearly-optimal. Such set systems are abstract, but they can be realized by simply-shaped regions, as halfspaces and balls in d-dimensions. Our analysis exploits the so-called “entropy method” and the technique of “partial coloring”, combined with the existence of small “packings”.

2 - Differential Privacy and Discrepancy Theory

Aleksandar Nikolov, Postdoc, Microsoft Research Redmond, Microsoft Research, Redmond, United States of America, a.t.nikolov@gmail.com

Differential privacy is a rigorous definition of what it means for a data analysis algorithm to preserve the privacy of the information of individuals. Recently, fascinating connections have been discovered between differential privacy and statistics, machine learning, convex geometry, and discrepancy theory, among others. In this talk we will describe this last connection and show how it allowed us to gain a nearly complete understanding of the amount of error that is necessary and sufficient to achieve differential privacy for any given set of counting queries.

3 - Constructive Discrepancy Minimization: Vector Coloring and Equivalence Relations

Daniel Dadush, CWI, Science Park, Amsterdam, Netherlands, dndadush@gmail.com, Aleksandar Nikolov

Given an n x n matrix A, the discrepancy minimization problem is to find a -1/1 coloring x minimizing the infinity norm of Ax. The Komlos conjecture is that if A has bounded column norms then there exists a coloring of constant discrepancy. We show that this conjecture holds for a natural SDP relaxation of discrepancy, together with a simple algorithm to construct an SDP solution. Additionally, we show an equivalence of a seminal result of Banaszczyk (proving Komlos up O(sqrt(log n))) with the existence distributions on x such that Ax is subgaussian.

■ FC28

28- Liberty Room

Vulnerability Analysis and Design of Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Neng Fan, Assistant Professor, University of Arizona, 1127 E. James E. Rogers Way Room 111, Tucson, AZ, 85721, United States of America, nfan@email.arizona.edu

1 - Diameter-Constrained Network Design Problems with Connectivity Requirements

Elham Sadeghi, Graduate Research Assistant, University of Arizona, United States of America, sadeghi@email.arizona.edu, Neng Fan

A connected graph is said to be k-vertex connected if the resulted graph after removal of fewer than k vertices is still connected. Also, a connected graph is called l-edge connected if the resulted graph after removal fewer than l edges,is still connected. The diameter d of a graph is the greatest distance between any pair of vertices. We combine the edge and vertex connectivity requirements with diameter constraint, by proposing integer programming models and designing algorithms, to design a minimum-cost network such that the resulted graph, after removal of at most k vertices and/or l edges, has diameter d.

2 - Integer Programming Approaches for Vulnerability Analysis of Interdependent Networks

Andres Garrido, Universidad de La Frontera, Antonio Varas 1195, Temuco, IX, Chile, amgarrido.ortiz@gmail.com, Neng Fan

In this talk, we analyze the vulnerability of interdependent networks by identify a set of nodes in power grid, whose removal results high impacts by the cascading failures in the interdependent communication network and itself. We propose an approach by integer programming to identify a set of nodes such that the the size of the largest connected component in the resulted network after cascading failures is minimized. Knowing the behavior of these networks can help to be more prepared before attacks and failures that may affect the power network supply and functionality.

■ FC29

29- Commonwealth 1

Mixed-Integer Nonlinear Programming

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Elmor Peterson, Retired, Systems Science Research and Consulting, 3717 Williamsborough Court, Raleigh, NC, 27609, United States of America, elmor.peterson@gmail.com

1 - Mixed-Integer Linearly-Constrained Convex Programming MILCCP Reduced to Unconstrained Convex Programming UCP

Elmor Peterson, Retired, Systems Science Research and Consulting, 3717 Williamsborough Court, Raleigh, NC, 27609, United States of America, elmor.peterson@gmail.com

A relaxation (without the integer constraints) is easily transformed (in a new way) into an equivalent convex “GGP problem” whose corresponding “Conjugate GGP Dual” is unconstrained and hence can be solved with any UCP algorithm — after which any cutting plane resulting from the easily-computed GGP primal-optimal solution readily produces a “GGP Dual Update” that is also unconstrained — and hence solvable without (relatively inefficient) branching, bounding, or cold re-starting. During each such iteration, vector parallel-processing can be directly used (without pre-processing) to solve some extra-large-scale or multi-scale problems (in LP, MILP, LCCP or MILCCP) that were previously unsolvable in real time. Finally, some related stochastic MILCCP problems can also be solved by this GGP methodology.

2 - A Global DC Programming Algorithm for Solving Mixed-01 Nonlinear Program

Yi-Shuai Niu, Professor, Shanghai Jiao Tong University, 800 Dong Chuan Rd., Shanghai, 200240, China, niuyishuai@sjtu.edu.cn

We propose a new hybrid method based on DC (Difference of convex functions) programming algorithm (DCA) combining with Branch-and-Bound (B&B), DC/SDP relaxation technique and DC-Cut for globally solving mixed-01 nonlinear program. We will firstly reformulate a mixed-01 nonlinear program as a DC program via continuous representation techniques and penalization techniques. Then we consider in B&B, an efficient local optimization algorithm DCA is proposed for searching upper bound. The DC/SDP relaxation will be constructed for lower bound estimation. And the DC-Cutting plane helps to cut off local minimizers, thus reduce the feasible set and accelerate the convergence of B&B. Some preliminary numerical results of our method will be reported.

■ FC30

30- Commonwealth 2

Approximation and Online Algorithms

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Ankur Kulkarni, Assistant Professor, Indian Institute of Technology Bombay, Powai, Mumbai, India, kulkarni.ankur@iitb.ac.in

1 - Efficient Approximation Schemes for Lot-Sizing in Continuous Time

Mathieu Van Vyve, Universitè catholique de Louvain, Voie du Roman Pays 34, Louvain-La-Neuve, 1348, Belgium, mathieu.vanvyve@uclouvain.be, Claudio Telha

We consider a continuous-time variant of the classical Economic Lot-Sizing (ELS) problem. In this model, the setup cost is a continuous function with lower bound Kmin > 0, the demand and holding costs are integrable functions of time and the replenishment decisions are not restricted to be multiples of a base period. This problem generalizes both the ELS and EOQ models. Assuming a one-dimensional optimization oracle, we describe approximation schemes that are polynomial in 1/eps and a variant of the size of the output.

2 - Exact and Approximation Algorithms for Weighted Matroid Intersection

Naonori Kakimura, University of Tokyo, 3-8-1 Komaba Meguro-ku, Tokyo, 153-8902, Japan, kakimura@global.c.u-tokyo.ac.jp, Chien-Chung Huang, Naoyuki Kamiyama

We give exact and approximation algorithms for the weighted matroid intersection problems. The core of our algorithms is a decomposition technique: we decompose the weighted version of the problem into a set of unweighted problems. The advantage of this approach is that we can then exploit fast unweighted matroid intersection algorithms as a black box. To be precise, we can find an exact solution via solving W unweighted problems, where W is the largest weight. Furthermore, we can find a (1-epsilon)-approximate solution via solving O(1/epsilon * log r) unweighted problems, where r is the smallest rank of the given two matroids. Our algorithms are simple and flexible: they can be adapted to specific matroid intersection problems.

Friday, 2:45pm - 4:15pm

■ FD01

01- Grand 1

Cutting Planes for Mixed-Integer Programs

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Oktay Gunluk, IBM Research, 1101 Kitchawan Road, Yorktown Heights, NY, United States of America, gunluk@us.ibm.com

1 - Cutting Planes from Extended LP Formulations

Sanjeeb Dash, IBM Research, 1101 Kitchawan Road, Yorktown Heights, United States of America, sanjeebd@us.ibm.com, Oktay Gunluk, Merve Bodur

We study “extended LP formulations” of mixed-integer programs (MIP) that give the original LP relaxation when projected down to the original space and show that split cuts applied to such formulations can be more effective than split cuts applied to the original formulation. For any 0-1 MIP with n integer variables, we give an extended LP formulation in 2n variables that has integral split closure. For general MIPs, we show that extended LP formulations may not give any additional strength over the original problem with respect to split cuts. We also study extended LP formulations of structured problems such as the stable set problem and the 2-row continuous group relaxation.

2 - On On-Off Polytopes

Laurence Wolsey, Emeritus Professor, CORE,University of Louvain, Voie du Roman Pays 34, Louvain-la-Neuve, 1348, Belgium, laurence.wolsey@uclouvain.be, Maurice Queyranne

The problem arising in production planning and unit commitment of switching a machine on/off with time-dependent minimum/maximum bounds on the length of the on/off periods, limits on the number of start-ups and the possibility of cold/hot starts is considered. Introducing new integer variables, the basic problem is formulated as a network dual problem providing among others simple integrality proofs, valid inequalities (alternating and others) and separation algorithms.

3 - Cut-Generating Functions for Integer Variables

Gerard Cornuejols, Carnegie Mellon Univ., Tepper School of Business, Pittsburgh, PA, United States of America, gc0v@andrew.cmu.edu, Sercan Yildiz

For an integer linear program, Gomory’s corner relaxation is obtained by ignoring the nonnegativity of the basic variables in a tableau formulation. In the present study, we do not relax these nonnegativity constraints. We generalize a classical result of Gomory and Johnson characterizing minimal cut-generating functions in terms of subadditivity, symmetry, and periodicity. Our result is based on a new concept, the notion of generalized symmetry condition. We also extend to our setting the 2-slope theorem of Gomory and Johnson for extreme cut-generating functions.

■ FD02

02- Grand 2

Convex Optimization Algorithms

Cluster: Conic Programming

Invited Session

Chair: Osman Guler, Professor, UMBC, 1000 Hilltop Circle, Baltimore, MD, 21250, United States of America, guler@umbc.edu

1 - Network Flow Problems with Convex Conic Constraints

Farid Alizadeh, Professor, Rutgers University, MSIS Department, 100 Rockefellar, Room 5142, Piscataway, NJ, 08854, United States of America, alizadeh@rci.rutgers.edu, Mohammad Ranjbar, Deniz Seyed Eskandani, Marta Cavaleiro

We consider network flow problems where arc capacities, costs, and node demand/supply are represented by vectors restricted to be in a proper cone K. For example, in time-varying problems, these parameters may be required to be coefficients of nonnegative polynomial functions of time. We examine challenges for extending familiar combinatorial algorithms such as augmenting path methods, or simplex (primal, dual, or primal-dual) algorithms to conic network flow problems. We also examine classical results such as the max-flow-min-cut theorem in the conic context.

2 - First-order Methods for Convex Programming and Monotone Operators

Osman Guler, Professor, UMBC, 1000 Hilltop Circle, Baltimore, MD, 21250, United States of America, guler@umbc.edu

Currently, there is considerable interest and demand for first-order algorithms that can effectively deal with large applications coming from machine learning and others. In this talk, we investigate acceleration schemes for such algorithms in the framework of convex optimization and monotone operator theory. We will consider a variety of tools to construct such methods, including continuous dynamical systems (odes), splitting, and duality.

■ FD03

03- Grand 3

Rectangle Packing in Chip Design

Cluster: Combinatorial Optimization

Invited Session

Chair: Stefan Hougardy, University of Bonn, Research Institute for Discrete Mathematics, Lennestr. 2, Bonn, 53113, Germany, hougardy@or.uni-bonn.de

1 - Optimal Ratios for Soft Packings of Rectangles

Ulrich Brenner, University of Bonn, Research Institute for Discrete Mathematics, Lennestr. 2, Bonn, 53113, Germany, brenner@or.uni-bonn.de

We consider the problem of packing a set of rectangles of total size 1 into a square A. The sizes of the single rectangles are given while we may choose their aspect ratios from a given interval [1,g]. As a main result, we will show that there is always a feasible solution if A has size at least max(4g/(4g-1), 2/g). This result generalizes an older theorem that showed that for g=1 a size of 2 for A is sufficient. Moreover, we will prove that this bound is tight.

2 - The Cut Rectangle Problem

Pascal Cremer, PhD Candidate, University of Bonn, Research Institute for Discrete Mathematics, Lennestr. 2, Bonn, 53113, Germany, cremer@or.uni-bonn.de

The Cut Rectangle Problem is to find n rectangles that all have the same width and must have some minimum height. In addition, the rectangles must fulfill certain requirements on their absolute and relative positions, for example, they are not allowed to overlap. The goal is then to maximize the total area of these rectangles. This problem appears as a subproblem in the fabrication of modern semiconductors with double patterning techniques. We present different versions of the Cut Rectangle Problem and prove the NP-hardness for some of them, while we present polynomial time algorithms for the others.

3 - BonnPlan: Floorplanning with Flexible Aspect Ratios

Jannik Silvanus, University of Bonn, Research Institute for Discrete Mathematics, Lennestr. 2, Bonn, 53113, Germany, silvanus@or.uni-bonn.de, Jan Schneider

In VLSI design, chips are often constructed hierarchically to both simplify the task and improve the solution quality. This is done by creating a floorplan that divides the chip into rectangular blocks and distributing cells to these blocks. The blocks can be designed independently and are later put together according to the floorplan. We present an algorithm that both computes a partition of the netlist into clusters and generates a floorplan with rectangular blocks for these clusters based on a flat placement of the netlist. The algorithm supports flexible aspect ratios for these blocks and uses a linear programming formulation to simultaneously optimize aspect ratios and positions of blocks.

■ FD04

04- Grand 4

Convex Relaxations and Applications in Statistical Learning

Cluster: Conic Programming

Invited Session

Chair: Alexandre d'Aspremont, 23 av d'Italie, Paris, France, aspremon@ens.fr

1 - Tightness of Convex Relaxations for Certain Inverse Problems on Graphs

Afonso Bandeira, Graduate Student, Princeton University, Program in Applied and Computational Mat, Fine Hall 2nd floor, Washington Rd, Princeton, NJ, 08544, United States of America, afonsobandeira@gmail.com

Many maximum likelihood estimation problems are known to be intractable in the worst case. A common approach is to consider convex relaxations of the maximum likelihood estimator, and relaxations based on semidefinite programming are among the most popular. We will focus our attention on a certain class of graph-based inverse problems.

2 - Semidefinite Relaxations for Angular Synchronization are Often Tight

Nicolas Boumal, Postdoctoral Researcher, Inria & ENS, 23 Avenue d'Italie, Paris, 75013, France, nicolasboumal@gmail.com, Amit Singer, Afonso Bandeira

We consider the problem of estimating phases (points on a circle) from noisy, pairwise, relative phase measurements. Assuming Gaussian noise, the maximum likelihood estimator (MLE) is the solution of a hard, nonconvex quadratically constrained quadratic program. The latter can be relaxed into a semidefinite program (SDP) by lifting (dropping a rank 1 constraint). Remarkably, this SDP turns out to be tight (i.e., it reveals the true MLE in polynomial time) with high probability, even in the face of large noise. We provide a proof of this statement in a preprint: http://arxiv.org/abs/1411.3272. Come see the talk for a quick tour and intuition!

3 - Decomposition Methods for Sparse Matrix Nearness Problems

Yifan Sun, University of California, Los Angeles, 420 Westwood Plaza, Los Angeles, CA, United States of America, ysun01@ucla.edu, Lieven Vandenberghe

We present decomposition methods for computing Euclidean projections on three types of sparse matrix cones with given sparsity patterns: sparse positive semidefinite matrices, and sparse matrices with a positive semidefinite or Euclidean distance completion. The methods combine clique decomposition results for chordal graphs with applications of first-order methods for convex optimization. They include the dual projected gradient method, the dual block coordinate ascent method (or Dykstra's method), and the Douglas-Rachford splitting method. A key feature of the methods is that they only require a series of projections on small dense matrix cones. We compare these methods on a set of test problems, with matrix sizes up to 100,000.

■ FD05

05- Kings Garden 1

Algorithms for Nonlinear Optimization Problems in Machine Learning

Cluster: Nonlinear Programming

Invited Session

Chair: Figen Oztoprak, Assistant Professor, Istanbul Bilgi University, Santral Istanbul, Eyup, Istanbul, Turkey, figen.topkaya@bilgi.edu.tr

1 - A Distributed Incremental Quasi-Newton Algorithm for Large-Scale Matrix Factorization

S. Ilker Birbil, Sabanci University, Orhanli-Tuzla, Istanbul, Turkey, sibirbil@sabanciuniv.edu, Umut Simsekli, Hazal Koptagel, A. Taylan Cemgil, Figen Oztoprak

We propose a distributed incremental quasi-Newton method for solving matrix factorization problems. The proposed method does not require convexity neither does it involve any randomness. We first present the algorithm and then discuss its convergence behavior. We also observe that our discussion, in fact, applies to a quite generic algorithm. This observation is significant as some other convergent algorithms along the same lines may be devised in the future. Finally, we conduct a comprehensive computational study indicating that the proposed algorithm performs very well for solving large-scale matrix factorization problems.

2 - Local Linear Convergence of ISTA and FISTA on the LASSO Problem

Shaozhe Tao, University of Minnesota, 111 Church Street SE, Minneapolis, MN, 55455, United States of America, taoxx120@umn.edu, Daniel Boley, Shuzhong Zhang

We establish local linear convergence bounds for the ISTA and FISTA iterations on the model LASSO problem. We show that FISTA can be viewed as an accelerated ISTA process. Using a spectral analysis, we show that, when close enough to the solution, both iterations converge linearly, but FISTA slows down compared to ISTA, making it advantageous to switch to ISTA toward the end of the iteration processs. We illustrate the results with some synthetic numerical examples.

3 - On Existing Theory Adapted for Recent Algorithms

Figen Oztoprak, Assistant Professor, Istanbul Bilgi University, Santral Istanbul, Eyup, Istanbul, Turkey, figen.topkaya@bilgi.edu.tr

We present some theoretical results regarding three recent algorithms that we have proposed for certain non-smooth and stochastic optimization problems motivated by machine learning applications. The main point of the talk is that all the results that we present do adapt or use existing theory developed for different problems at different contexts; in particular, from linear complementarity, semismooth-Newton, and matrix convergence literature.

■ FD06

06- Kings Garden 2

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Luigi De Giovanni, Dipartimento di Matematica, Padova, 35121, Italy, luigi.degiovanni@unipd.it

1 - Disjunctive Cuts for Large Formulations

Stefan Ropke, Danmarks Tekniske Universitet, Produktionstorvet, building 426, Kgs. Lyngby, 2800, Denmark, ropke@dtu.dk

This talk presents a computational experiment where disjunctive cuts are generated from formulations with a large number of constraints, implicitly represented using separation oracles. The disjunctive cuts themselves are found by solving a cut finding LP using column generation. Results in terms of lower bounds on the Dantzig, Fulkerson and Johnson model for the asymmetric and symmetric TSP, as well as for the capacitated vehicle routing problem (CVRP) are presented. Some preliminary results showing the effect of using the disjunctive cuts inside a branch-and-cut algorithm for the CVRP are reported as well.

2 - New Facets for the Consecutive Ones Polytope

Luigi De Giovanni, Universita di Padova, Dipartimento di Matematica, via Trieste, 63, Padova, 35121, Italy, luigi@math.unipd.it, Laura Brentegani, Mattia Festa

A 0/1 matrix has the Consecutive-Ones Property if a permutation of its columns makes the ones consecutive in every row. In many applications, one has to find an optimal matrix with this property, and literature proposes Integer Linear Programming formulations based on Tucker (1972) characterization and on classes of facet defining inequalities (Oswald and Reinelt, 2004). We propose a graph-based method to derive new classes of facets and we embed them in a branch-and-cut algorithm.

3 - Communicating with External Heuristic Solvers to Improve the Performance of MIP Solvers

Shunji Umetani, Osaka University, 2-1 Yamadaoka, Suita, Osaka, Japan, umetani@ist.osaka-u.ac.jp, Yuji Shinano

The progress of internal primal heuristics of MIP solvers has much improved their performance in recent years. However, external heuristic solvers still achieve better primal bounds than MIP solvers for many combinatorial optimization problems. We develop a parallel extension of MIP solvers that communicate with external heuristic solvers to improve their performance.

■ FD07

07- Kings Garden 3

Combinatorial Optimization and Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Warren Adams, Professor, Clemson University, Clemson, SC, 29634, United States of America, wadams@clemson.edu

1 - Solvable Instances of the Quadratic Assignment Problem via the Reformulation-Linearization Technique

Warren Adams, Professor, Clemson University, Clemson, SC, 29634, United States of America, wadams@clemson.edu, Lucas Waddell

Due to the difficulty associated with solving the NP-hard quadratic assignment problem (QAP), a research direction has been to identify objective function structures that allow polynomial solvability. Accordingly, a QAP instance has been defined in the literature to be “linearizable” if it can be rewritten as a linear assignment problem that preserves the objective value at all feasible points. We show that every linearizable instance of the QAP can be characterized in terms of the continuous relaxation of the level-1 reformulation-linearization technique (RLT) form, and that this program will have a binary optimal extreme point that solves the QAP for every such instance. As a consequence, we identify the dimension of the level-1 RLT form.

2 - A Risk-Averse Multistage Generalized Network Flow Model for Water Allocation

Guzin Bayraksan, Associate Professor, Ohio State University, 1971 Neil Ave., Columbus, OH, 43210, United States of America, bayraksan.1@osu.edu

We formulate a water allocation problem by risk-averse multistage programming, which has the advantage of controlling high-risk severe water shortage events. We consider five decompositions of the resulting risk-averse model in order to solve it via the nested L-shaped method. We introduce separate approximations of the mean and the risk measure and also investigate the effectiveness of multiple cuts. In numerical experiments we (1) present a comparative computational study of the risk-averse nested L-shaped variants and (2) analyze the risk-averse approach to the water allocation problem.

3 - A Branch-and-Cut Method for Solving the Bilevel Clique Interdiction Problem

Tim Becker, Rice University, 1330 Old Spanish Trail, Apt 4305, Houston, TX, United States of America, tjbecker04@gmail.com

I introduce an algorithm to solve the current formulation of the bilevel clique interdiction problem. The problem defines a defender who attempts to minimize the number of cliques removed by an attacker. The algorithm presented in this talk uses a branch and cut approach to solve the proposed problem and give preliminary results. This algorithm is expected to be usable on any social network, thereby improving the study of many network problems including terrorist cells or marketing strategies.

■ FD08

08- Kings Garden 4

Structured Optimization in High Dimensional Inference

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Alexandr Aravkin, IBM T.J. Watson Research Center, 1101 Kitchawan Rd., Yorktown Heights, NY, 10598, United States of America, sasha.aravkin@gmail.com

1 - Composite Self-Concordant Minimization

Anastasios Kyrillidis, PostDoc, University of Texas at Austin, 1616 Guadalupe, UTA 6.416, Austin, TX, 78751, United States of America, anastasios@utexas.edu, Quoc Tran-Dinh, Volkan Cevher

We propose a variable metric framework for minimizing the sum of a self-concordant function and a possibly non-smooth convex function, endowed with an easily computable proximal operator. We theoretically establish the convergence of our framework without relying on the usual Lipschitz gradient assumption on the smooth part. An important highlight of our work is a new set of analytic step-size selection and correction procedures based on the structure of the problem. We describe concrete algorithmic instances of our framework for several interesting applications and demonstrate them numerically on both synthetic and real data.

2 - Compressed Sensing with Support Information

Hassan Mansour, Mitsubishi Electric Research Laboratories (MERL), mansour@merl.com, Rayan Saab

Compressed sensing is a signal acquisition paradigm that uses the sparsity of a signal to efficiently reconstruct it from very few linear measurements. These measurements often take the form of inner products with random vectors drawn from appropriate distributions, and the reconstruction is typically done using convex optimization algorithms or computationally efficient greedy algorithms. Under the additional, often practical, assumption that we have a possibly inaccurate estimate of the support we discuss using weighted l1-norm minimization as a reconstruction method. We give reconstruction guarantees that improve on the standard results when the support information is accurate enough and when the weights are chosen correctly.

3 - Embracing the Non-convexity of Low-rank Matrix Estimation

Sujay Sanghavi, University of Texas, sanghavi@mail.utexas.edu

Fitting a low-rank matrix to data is a fundamental step in several modern data applications. It is commonly posed as an optimization problem over the set of low-rank matrices - making it inherently non-convex due to the non-convexity of the set of low-rank matrices. In this talk we focus on settings where this is the “only” source of non-convexity; that is, the optimization of (certain) convex functions over this set. We show that - under the common statistical assumptions which guarantee the consistency of recently popular convex relaxations - one can also establish the consistency of much faster procedures that operate directly on the efficient but non-convex factored form of the low-rank matrix.

■ FD09

09- Kings Garden 5

Large-Scale Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Roummel Marcia, Associate Professor, University of California, Merced, 5200 N. Lake Road, Merced, CA, 95343, United States of America, rmarcia@ucmerced.edu

1 - A High-accuracy Sr1 Trust-region Subproblem Solver for Large-scale Optimization

Jennifer Erway, Associate Professor, Wake Forest University, Winston-Salem, NC, United States of America, erwayjb@wfu.edu, Roummel Marcia, Johannes Brust

In this talk we present an SR1 trust-region subproblem solver for large-scale unconstrained optimization. This work makes use the exact leftmost eigenvalue, obtainable from the compact representation of an SR1 matrix, to address the so-called “hard case”. In all cases, we are able to obtain high-accuracy solutions. Numerical results will be presented.

2 - Preconditioning for Optimization Problem with Nonlocal Operators

Ekkehard Sachs, University of Trier, Trier, Germany, sachs@uni-trier.de

Nonlocal operators occur in peridynamics, cell adhesion processes and the modeling of option prices of jump diffusion type. Optimization comes into play when parameters have to be estimated by fitting the output data. It is obvious that for a fast numerical solution preconditioning is essential. Often the point of view is taken that the diffusive, i.e. local, part of the operator needs preconditioning whereas the integral, i.e. nonlocal part is of smoothing type, even a compact operator, and hence no preconditioning is necessary. However, we show in this talk that this is misleading because the smoothing property depends strongly on the shape of the distribution function or kernel. We underscore this observation by numerical experiments.

3 - Recent Developments in SQP Methods for Large-Scale Nonlinear Optimization

Elizabeth Wong, University of California, San Diego, Department of Mathematics, 9500 Gilman Drive, # 0112, La Jolla, CA, 92093-0112, United States of America, elwong@ucsd.edu, Philip E. Gill, Michael Saunders

We discuss some practical issues associated with the formulation of sequential quadratic programming (SQP) methods for large-scale nonlinear optimization. Numerical results are presented for the software package SNOPT, which uses a positive-definite quasi-Newton approximate Hessian or an exact Hessian.

■ FD10

10- Kings Terrace

Stochastic Programming in Financial Engineering

Cluster: Finance and Economics

Invited Session

Chair: Pavlo Krokhmal, University of Iowa, pavlo-krokhmal@uiowa.edu

1 - Weak Continuity of Risk Functionals with Applications to 2-stage Stochastic Programming

Matthias Claus, Universitaet Duisburg-Essen, Thea-Leymann-Str. 9, Essen, Germany, matthias.claus@uni-due.de, Ruediger Schultz

Measuring and managing risk has become crucial in modern decision making under stochastic uncertainty. In 2-stage stochastic programming, mean risk models are essentially defined by a parametric recourse problem and a quantification of risk. From the perspective of qualitative robustness theory, we discuss sufficient conditions for continuity of the resulting objective functions with respect to perturbation of the underlying probability measure. Our approach covers a fairly comprehensive class of both stochastic-programming related risk measures and relevant recourse models and allows us to extend known stability results for two-stage stochastic programs to models with mixed-integer convex recourse and quadratic integer recourse.

2 - Scenario-Tree Decomposition: Bounds for Multistage Stochastic Mixed-Integer Programs

Gabriel Lopez Zenarosa, PhD Candidate, University of Pittsburgh, 3700 O’Hara Street, Benedum Hall 1048, Pittsburgh, PA, 15261-3048, United States of America, glz5@pitt.edu, Oleg A. Prokopyev, Andrew J. Schaefer

Multistage stochastic mixed-integer programming is a powerful modeling paradigm appropriate for many problems involving a sequence of discrete decisions under uncertainty; however, they are difficult to solve. We present scenario-tree decomposition to establish bounds for multistage stochastic mixed-integer programs. Our method decomposes the scenario tree into a number of smaller trees using vertex cuts and combines the solutions of the resulting subproblems to generate bounds. We developed a multithreaded implementation of our method to solve the “embarrassingly parallel” subproblems and evaluated it on test instances from the existing literature. We found our bounds to be competitive with those of a state-of-the art commercial solver.

3 - On the Value of More Stages in Stochastic Programming Models for Portfolio Optimization

Jonas Ekblom, PhD Student, Linköping University, Linköpings Universitet, Linköping, 58183, Sweden, jonas.ekblom@liu.se, John Birge

We compare the performance of two- and multi-stage Stochastic Programming models for portfolio optimization. What is the value of more stages and how does it compare to a finer discretization of the underlying distribution? We study the impact of e.g. different risk aversion, a time-varying investment opportunity set, and the size of transaction costs. We also investigate how, within a single period model, the transaction costs should be set to maximize a long-run objective.

■ FD11

11- Brigade

Convexification Techniques for Structured Problems

Cluster: Global Optimization

Invited Session

Chair: Fatma Kilinc-Karzan, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, fkilinc@andrew.cmu.edu

1 - A Cut Generating Procedure for Cardinality Constrained Optimization Problems (CCOP)

Jinhak Kim, Purdue University, 2353 Yeager Rd Apt 10, West Lafayette, IN, 47906, United States of America, kim598@purdue.edu, Mohit Tawarmalani, Jean-Philippe P. Richard

We develop cutting planes for CCOP that separate the optimal solution of the LP relaxation. Using the optimal simplex tableau, the feasible region of CCOP is relaxed as a disjunctive set in the space of the nonbasic variables. Then, the facet-defining inequalities for the disjunctive set are shown to correspond to extreme solutions of the dual of a transportation problem. The coefficients of the facet-defining inequalities obey ratios that can be obtained from the simplex tableau. The ratios that are eventually tight form a label-connected tree. This allows us to generalize the equate-and-relax procedure recently developed for complementarity problems to CCOP.

2 - On Binary Optimization Problems with Bounded Tree-Width

Gonzalo Munoz, Columbia University, 500 W. 120nd Street, New York, NY, 10027, United States of America, gonzalo@ieor.columbia.edu, Daniel Bienstock

We describe an LP formulation for pure binary optimization problems where individual constraints are available through a membership oracle; the formulation is exact and if the intersection graph for the constraints has bounded tree-width our construction is of linear size. This improves on a number of results in the literature, both from the perspective of formulation size and generality, and it also yields to a class of linear programming approximations for mixed-integer polynomial optimization problems that attain any desired tolerance.

3 - Disjunctive Cuts for the Second-Order Cone and its Cross-Sections

Sercan Yildiz, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, syildiz@andrew.cmu.edu, Fatma Kilinc-Karzan, Gerard Cornuejols

We study the convex hull of a two-term disjunction on the second-order cone (SOC). We exploit the structure of undominated valid linear inequalities and derive a family of convex inequalities describing the resulting convex hull. We identify cases where these convex inequalities can be expressed in SOC form and where a single inequality from this family is sufficient to describe the convex hull. In more recent work, we extend these results to cross-sections of the SOC. We show that a single convex inequality is sufficient to characterize the convex hull of all two-term disjunctions on ellipsoids and paraboloids and a wide class of two-term disjunctions -including split disjunctions- on hyperboloids.

■ FD13

13- Rivers

Randomized, Distributed, and Primal-Dual Methods II

Cluster: Nonsmooth Optimization

Invited Session

Chair: Peter Richtarik, Professor, University of Edinburgh, Peter Guthrie Tait Road, EH9 3FD, Edinburgh, EH9 3FD, United Kingdom, peter.richtarik@ed.ac.uk

1 - Distributed Optimization with Arbitrary Local Solvers

Jakub Konecny, University of Edinburgh, James Clerk Maxwell Building, Peter Guthrie Tait Road, Edinburgh, EH9 3FD, United Kingdom, kubo.konecny@gmail.com

With the growth of data businesses collect, problems needed to be solved are not suitable for usual optimization techniques. When the data are large so that it cannot be stored on a single computer, communication between individual computers is a significant bottleneck. In this work we develop a general primal-dual framework for distributed optimization. We formulate different ways of formulating local subproblems, which are solved approximately on each computer independently, using an arbitrary optimization algorithm. We provide experiments that demonstrate the strength of the framework and possibility of using various local optimization algorithms.

2 - Randomized Dual Coordinate Ascent with Arbitrary Sampling

Zheng Qu, Dr., University of Edinburgh, James Clerk Maxwell Building, Peter Guthrie Tait Road, Edinburgh, EH9 3FD, United Kingdom, zheng.qu@ed.ac.uk

We study the problem of minimizing the average of a large number of smooth convex functions penalized with a strongly convex regularizer. We propose and analyze a novel primal-dual method (Quartz) which at every iteration samples and updates a random subset of the dual variables, chosen according to an arbitrary distribution. Depending on the choice of the sampling, we obtain efficient serial, parallel and distributed variants of the method. Our bounds match the best known bounds for SDCA in the serial case and with standard mini-batching predict data-independent speedup as well as additional data-driven speedup which depends on spectral and sparsity properties of the data.

3 - Convergence Analysis of Block-Coordinate Primal-Dual Algorithms with Arbitrary Random Sampling

Audrey Repetti, University of Paris-Est, 5, Boulevard Descartes, Champs sur Marne, Marne la Vallee Cedex 2, 77454, France, audrey.repetti@u-pem.fr, Jean-christophe Pesquet, Emilie Chouzenoux

In many application areas, one must solve minimization problems involving the sum of proper lower-semicontinuous convex functions composed with linear operators. Such problems can be efficiently solved using primal-dual proximal algorithms. When the number of variables is very large, it can be interesting to adopt a block-coordinate strategy in order to limit the occupied memory. In this work, we propose two subclasses of block-coordinate primal-dual algorithms based on the forward-backward iterative scheme. At each iteration, only a subpart of the variables, selected with an arbitrary random rule, is updated. The almost sure convergence of the iterates generated by the algorithms to a solution of the considered problem is proved.

■ FD16

16- Sterlings 1

Risk-Constrained Stochastic Programs

Cluster: Stochastic Optimization

Invited Session

Chair: James Luedtke, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53706, United States of America, jrluedt1@wisc.edu

1 - Decomposition Algorithms for Two-Stage Chance-Constrained Programs

Xiao Liu, Ohio State University, 320 Baker Systems Building 1971 Neil Ave, Columbus, 43202, United States of America, liu.2738@buckeyemail.osu.edu, Simge Kucukyavuz, James Luedtke

We study a class of chance-constrained two-stage stochastic optimization problems where second-stage feasible recourse decisions incur additional cost. In addition, we propose a new model, where ``recovery” decisions are made for the infeasible scenarios to obtain feasible solutions to a relaxed second-stage problem. We develop decomposition algorithms with specialized optimality and feasibility cuts to solve this class of problems. Computational results on a chance-constrained resource planing problem indicate that our algorithms are highly effective in solving these problems compared to a mixed-integer programming reformulation and a naive decomposition method.

2 - Nonanticipative Duality, Relaxations, and Formulations for Chance-Constrained Stochastic Programs

Weijun Xie, Georgia Institute of Technology, School of ISYE, 755 Ferst Drive, NW, Atlanta, GA, 30332-0205, United States of America, wxie33@gatech.edu, Yongjia Song, Shabbir Ahmed, James Luedtke

We propose two new Lagrangian dual problems for chance-constrained stochastic programs based on relaxing nonanticipativity constraints. We compare the strengths of the associated dual bounds and derive two new related primal formulations. We demonstrate that for chance-constrained linear programs, the continuous relaxations of these primal formulations yield bounds equal to the proposed dual bounds. We propose a new heuristic method and two new exact algorithms based on these duals and formulations, and present computational evidence demonstrating their effectiveness.

3 - Cut Generation in Optimization Problems with Multivariate Risk Constraints

Nilay Noyan, Associate Professor, Sabanci University, Sabanci University, Istanbul, Turkey, nnoyan@sabanciuniv.edu, Simge Kucukyavuz

We consider a class of multicriteria stochastic optimization problems that features benchmarking constraints based on conditional value-at-risk and second-order stochastic dominance. We develop alternative mixed-integer programming formulations and solution methods for cut generation problems arising in optimization under such multivariate risk constraints. We give the complete linear description of two non-convex substructures appearing in these cut generation problems. We present computational results that show the effectiveness of our proposed models and methods.

■ FD17

17- Sterlings 2

New Multiobjective Optimization Methods

Cluster: Multi-Objective Optimization

Invited Session

Chair: Kenza Oufaska, International University of Rabat, ELIT, Technopolis Rabat-Shore Rocad, Rabat - Salé, Morocco, Kenza.oufaska@uir.ac.ma

1 - Output-Sensitive Complexity of Multiobjective Combinatorial Optimization Problems

Fritz Bökler, TU Dortmund, Otto-Hahn-Strasse 14, Dortmund, 44227, Germany, fritz.boekler@tu-dortmund.de, Petra Mutzel

In this talk, we study output-sensitive algorithms and complexity for multiobjective combinatorial optimization (MOCO) problems. We develop two methods for enumerating the extreme nondominated points of MOCO problems and prove their output-sensitive running time for each fixed number of objectives under weak assumptions on the MOCO problem. Further, we show the practicability of the algorithms. On the negative side, we show a few first results on the output sensitive complexity of multiobjective shortest path problems.

2 - A New Method for Multi-Objective Optimization

Kenza Oufaska, International University of Rabat, ELIT, Technopolis Rabat-Shore Rocad, Rabat - Salé, Morocco, Kenza.oufaska@uir.ac.ma, Khalid El Yassini

Optimization problems often have several conflicting objectives to be improved simultaneously. It is important to turn to a multi-objective (MO) type of optimization which offers all compromise solutions. In this work, we propose a new approach by using, iteratively, the e-constraint method to generate better bounds for all objective functions of the problem. Several approaches can contribute including the penalty method. Thereafter, we proceed to a transformation to a weighted single-objective problem with new constraints on the initial objectives.

■ FD18

18- Sterlings 3

Paths to Smoothing in Convex Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: James Burke, Prof., University of Washington, Box 354350, Seattle, WA, 98195, United States of America, jvburke@uw.edu

1 - A New Class of Matrix Support Functionals with Applications

Tim Hoheisel, PostDoc, University of Würzburg, Campus Hubland Nord, Emil-Fischer-Strasse 30, Würzburg, 97074, Germany, hoheisel@mathematik.uni-wuerzburg.de, James Burke

A new class of matrix support functionals is presented which establish a connection between optimal value functions for quadratic optimization problems, the matrix-fractional function, the pseudo matrix-fractional function, the nuclear norm, and multi-task learning. The support function is based on the graph of the product of a matrix with its transpose. Closed form expressions for the support functional and its subdifferential are derived. In particular, the support functional is shown to be continuously differentiable on the interior of its domain, and a formula for the derivative is given when it exists.

2 - Iterative Re-Weighted Linear Least Squares for Exact Penalty Subproblems on Products Sets

Jiashan Wang, University of Washington, Box 354350, Seattle, WA, 98195, United States of America, jsw1119@uw.edu, James Burke, Frank E. Curtis, Hao Wang

We present two matrix-free methods for solving exact penalty subproblems on product sets that arise when solving large-scale optimization problems. The first approach is a novel iterative re-weighting algorithm (IRWA), which iteratively minimizes quadratic models of relaxed subproblems while automatically updating a relaxation vector. The second approach is based on alternating direction augmented Lagrangian (ADAL) technology applied to our setting. Global convergence and complexity are established for both algorithms.

3 - Level Sets Methods in Convex Optimization

James Burke, Professor, University of Washington, Box 354350, Seattle, WA, 98195, United States of America, jvburke@uw.edu, Alexandr Aravkin, Dmitriy Drusvyatskiy, Michael P. Friedlander, Scott Roy

We present an algorithmic framework for solving convex optimization problems by exchanging the the objective with one of the constraint functions. The approach has classical origins and is the basis for the SPGL1 algorithm of Van den Berg and Friedlander. In this talk we discuss a general framework for these methods, their complexity, and their numerical performance on a range of applications.

■ FD19

19- Ft. Pitt

Combinatorial Problems in Scheduling and Routing

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Daniele Catanzaro, Assistant Professor, Université Catholique de Louvain, Chaussée de Binche 151, bte M1.01.01, Mons, 7000, Belgium, daniele.catanzaro@uclouvain.be

1 - Multi-Vehicle Arc Routing Connectivity Problem (K-ARCP)

Vahid Akbarighadikolaei, PhD Candidate, Koc University, Rumelifeneri Yolu, Koc Univeristy, Sariyer, Istanbul, 34450, Turkey, vakbarighadkolaei@ku.edu.tr, Fatma Sibel Salman

We define an emergency road clearing problem with the goal of restoring network connectivity in the shortest time. Given a set of closed edges, teams positioned at depot nodes are dispatched to open a subset of them that reconnects the network. Closed roads are traversable only after they are cleared by one of the teams. The problem is to find efficient coordinated routes for the clearing teams that: 1) connectivity of the network is regained, and 2) none of the closed roads are traversed unless their unblocking/clearing procedure is finished. In this study we develop two exact mixed integer programming formulation to solve this problem. Furthermore, we propose a local search algorithm to improve heuristic methods used in the literature.

2 - Exact Solution Frameworks for the Consistent Traveling Salesman Problem

Anirudh Subramanyam, Graduate Student, Carnegie Mellon University, DH3122, 5000, Forbes Ave., Pittsburgh, PA, 15213, United States of America, asubramanyam@cmu.edu, Chrysanthos Gounaris

We present two exact approaches for the Consistent Traveling Salesman Problem (ConTSP), a routing problem in which arrival-time consistency across multiple periods is enforced for each customer. For our first approach, which is based on branch-and-cut, we compare alternative formulations and we propose a new class of cutting planes to enforce consistency dynamically. For our second approach, which is based on decomposing the ConTSP into a sequence of single-period TSPs with time windows, we enforce consistency implicitly by successively tightening the time windows during a branch-and-bound process with separable branching rules. We compare our two approaches on a set of benchmark instances derived from the TSPLIB.

3 - Improved Integer Linear Programming Formulations for the Job Sequencing and Tool Switching Problem

Daniele Catanzaro, Assistant Professor, Université Catholique de Louvain, Chaussée de Binche 151, bte M1.01.01, Mons, 7000, Belgium, daniele.catanzaro@uclouvain.be, Luis Neves Gouveia, Martine Labbé

We investigate the job Sequencing and tool Switching Problem (SSP), a NP-hard combinatorial optimization problem arising from computer and manufacturing systems. Starting from the results described in Tang and Denardo (1987), Crama et al. (1994) and Laporte et al. (2004), we develop new integer linear programming formulations for the problem that are provably better than the alternative ones currently described in the literature. Computational experiments show that the lower bound obtained by the linear relaxation of the considered formulations improve, on average, upon those currently described in the literature and suggest, at the same time, new directions for the development of future exact solution approaches.

■ FD20

20- Smithfield

Uncertainty Management in Healthcare

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Omid Nohadani, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208-3119, United States of America, nohadani@northwestern.edu

1 - Reliable Facility Location Model for Disaster Response

Osman Ozaltin, North Carolina State University, Raleigh, NC, United States of America, oyozalti@ncsu.edu, Abdelhalim Hiassat, Fatih Safa Erenay

We formulate a reliable facility location model for disaster response, and consider the problem of staffing aid facilities with volunteers. Candidate facility locations might become unavailable after the disaster, and volunteers serve at available facilities based on their preferences. We decompose the problem into volunteer subproblems and propose a Lagrangian-based branch-and-bound method. Our computational results show the efficiency of the solution approach and the significance of incorporating volunteer preferences into the model.

2 - Robust Fractionation in Radiotherapy

Ali Ajdari, University of Washington, BOX 352650, Seattle, Wa, 98195, United States of America, ali.adr86@gmail.com, Archis Ghate

The optimal fractionation problem in radiotherapy involves finding the number of treatment sessions and the corresponding doses in each session. The linear-quadratic dose-response model is commonly used to formulate this problem. One criticism of this approach is that the parameters of this dose-response model are not known. We provide a robust optimization framework to tackle this uncertainty in fractionation problems.

3 - Robust Parameter Estimation for Multi-Objective Radiation Therapy Planning

Omid Nohadani, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208-3119, United States of America, nohadani@northwestern.edu, Arkajyoti Roy

Radiation therapy planning is an inverse problem. To guide this iterative process, institutional and standardized recommendations for planning and quality assurance are followed. In practice one or more goals cannot be satisfied, leading to trade-offs. We present the analysis of a large set of clinical cases, revealing sizable uncertainties in human decisions. For reliable observations, we present a framework for robust estimators. It is shown that the treatment planning process often inherently prevents the clinical goals to be concurrently satisfied. The results shed new insights on the multi-objective optimization methodology in the presence of uncertainties.

■ FD21

21-Birmingham

Models for Integration of Intermittent and Decentralized Energy

Cluster: Optimization in Energy Systems
Invited Session

Chair: Yves Smeers, Center for Operations Research and Econometrics, Voie du Roman Pays, 34, Louvain-la-Neuve, 1348, Belgium, yves.smeers@uclouvain.be

1 - Analyzing Unilateral Market Power in Two-Settlement Electricity Market

Mahir Sarfati, KTH Royal Institute of Technology, Electric Power Systems, Teknikringen 33, Stockholm, 10044, Sweden, sarfati@kth.se, Mohammad Reza Hesamzadeh

This paper studies single-dominant producer's bidding behavior in two-settlement electricity markets in the presence of wind power integration. The day-ahead market and the real-time market are formulated as two MPEC problems. One MPEC is solved at a time and the results are fed into the other MPEC iteratively. In each iteration, the total profit from both markets will improve until an equilibrium point is found. The numerical results show effectiveness of the developed model.

2 - Impact of Inter- and Intra-regional Coordination in Markets with a Large Renewable Component

Stefanos Delikaraoglou, PhD Candidate, Technical University of Denmark, Akademivej, Building 358, Kgs. Lyngby, 2800, Denmark, stde@elektro.dtu.dk, Juan Miguel Morales Gonzalez, Pierre Pinson

The uncertainty associated with the forecast errors of stochastic renewables calls for revised market designs to enable spatial and temporal integration of day-ahead and balancing trading floors. In the absence of a specific target model for the European balancing market, we introduce a framework to compare different inter- and intra-regional coordination schemes that may emerge towards a complete pan-European electricity market. The proposed models are formulated as stochastic equilibrium problems and compared against an optimal setup that achieves full spatio-temporal market coupling. The simulation results reveal significant efficiency loss in case of partial coordination and diversity of market structure among regional power systems.

3 - Effect of Ramping Requirement and Price Cap on Energy Price in a System with High Wind Penetration

Sebastian Martin, sebastian.ii05@gmail.com, Yves Smeers, Jose Aguado

The European power market is currently retiring or mothballing large capacities of conventional plants, and at the same time incorporating a significant amount of non-dispatchable renewable generation, in particular wind. We analyse the mothballing process (and the resulting system) and study how they are affected by a price cap implemented in the energy only market, and by a possible implementation of ramping products in the system.

■ FD22

22- Heinz

Mechanism Design without Money

Cluster: Game Theory
Invited Session

Chair: Vasilis Gkatzelis, Stanford University, 353 Serra Street, Stanford, CA, 94305, United States of America, gkatz@cs.stanford.edu

1 - Who to Trust for Truthfully Maximizing Welfare?

Dimitris Fotakis, Assistant Professor, National Technical University of Athens, Iroon Polytechneiou 9, Athens, 15780, Greece, fotakis@cs.ntua.gr, Christos Tzamos, Emmanouil Zampetakis

We introduce a general approach based on selective exact verification and obtain approximate mechanisms without money for maximizing the social welfare in general domains. Having a good allocation in mind, a mechanism with verification selects few critical agents and detects, using verification, whether they report truthfully. If yes, the mechanism produces the desired allocation. Otherwise, the mechanism ignores any misreports. We obtain randomized truthful mechanisms without money that verify only ln(m)/\eps agents, where m is the number of outcomes, and are (1-\eps)-approximate for the social welfare. A remarkable property of our mechanisms is robustness, namely that their outcome depends only on the reports of the truthful agents.

2 - One-Dimensional Strategyproof Facility Location

Itai Feigenbaum, Columbia University, United States of America, iif2103@columbia.edu, Jay Sethuraman, Chun Ye

Consider a set of agents on an interval, where a planner wishes to locate a facility so as to maximize some social benefit function. The agents have linear preferences over the location of the facility, and their locations are unknown to the planner. Thus, the planner wishes to locate the facility in a strategyproof manner while approximating social benefit. We discuss mechanisms, lower bounds, and characterizations for various versions of this model.

3 - Truthful Mechanisms for Generalized Assignments

Nick Gravin, PostDoc, Microsoft Research New England, One Memorial Drive, Cambridge, Ma, 02142, United States of America, ngravin@microsoft.com, Ning Chen, Pinyan Lu

A set of jobs is to be assigned to a set of machines with given capacity constraints. In the generalized assignment problem every job-machine pair has a specific value and specific capacity for the assignment. The goal is to find an assignment that maximizes the sum of values under machine capacity constraints. [Dughmi and Ghosh '10] proposed a mechanism design framework in which jobs behave selfishly, each aiming to maximize its own value in the assignment. We give a poly-time algorithm that achieves constant approximation to the optimal assignment and satisfies necessary incentive requirements.

■ FD23

23- Allegheny

Finding Subgraphs

Cluster: Combinatorial Optimization
Invited Session

Chair: Bernard Knueven, University of Tennessee, 504 John D. Tickle Building, 851 Neyland Drive, Knoxville, TN, 37996, United States of America, bknueven@vols.utk.edu

1 - Maximal Induced k-regular Subgraphs

Torkel Andreas Haufmann, University of Oslo, Department of Mathematics, N. H. Abels Hus, Moltke Moes vei 35, Oslo, 0851, Norway, torkelah@math.uio.no, Agostinho Agra, Geir Dahl, Sofia Pinheiro

An induced k-regular subgraph is a graph induced by a subset of the vertices, such that each vertex has degree k in the induced graph. We consider the problem of finding the largest cardinality subset of vertices inducing a k-regular subgraph. This covers the problems of finding maximal independent sets, induced matchings, minimum-length cycles and maximal cliques. This problem is known to be NP-hard in general. A review of existing bounds relating to the adjacency matrix and the (signless) Laplacians is given, and some computational and theoretical results are presented for an integer linear programming formulation. Furthermore, some results on a tractable special case are given: When k = 1 and the graph is a tree.

2 - Almost Symmetries in Graphs

Bernard Knueven, University of Tennessee,
504 John D. Tickle Building, 851 Neyland Drive, Knoxville, TN,
37996, United States of America, bknueven@vols.utk.edu,
Sebastian Pokutta, Jim Ostrowski

This work addresses the following question. Given an arbitrary graph, G, and a budget, k, find a subgraph of G formed by removing at most k edges that contains the most symmetry. If such a subgraph contains non-trivial symmetries, we call the symmetries "almost symmetries". We discuss how to find such symmetries and the effect these have on solving combinatorial optimization problems.

3 - Packing Non-zero A-paths via Matroid Matching

Yutaro Yamaguchi, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku,
Tokyo, Japan, yutaro_yamaguchi@mist.i.u-tokyo.ac.jp,
Shin-ichi Tanigawa

A group-labeled graph is a directed graph in which each edge is associated with an element of a group. For a vertex subset A, a path is called a non-zero A-path if it starts and ends in A and the ordered product of the labels along it is not the identity. We show that the problem of packing non-zero A-paths reduces to the matroid matching problem, and discuss the efficient solvability via such a reduction.

■ FD24

24- Benedum

Convex Relaxations of Mixed-Integer Quadratic Programming Problems

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Juan Pablo Vielma, MIT, 100 Main Street, E62-561, Cambridge, MA, 02142, United States of America, jvielma@mit.edu

1 - Polyhedral Relaxations for Discrete Product Terms in Nonconvex 0/1 MINLPs

Akshay Gupte, Clemson University, Department of Mathematical
Sciences, Clemson, SC, 29634, United States of America,
agupte@clemson.edu, Shabbir Ahmed, Santanu Dey

We study polyhedral relaxations in the original space for constraints defined by sum of product of continuous variable and monotone function of 0/1 variables. This substructure appears frequently in nonconvex 0/1 MIQCPs and more general MINLPs. We exploit the supermodular structure in this set and devise a cut generation scheme. Under certain assumptions, the convex hull is described explicitly by tilting appropriate inequalities. We also discuss aggregation of valid inequalities.

2 - Convex Hull of Two Quadratic or a Conic Quadratic and a Quadratic Inequality

Sina Modaresi, PhD Student, University of Pittsburgh, 1048
Benedum Hall, Pittsburgh, PA, 15261, United States of America,
sim23@pitt.edu, Juan Pablo Vielma

We consider an aggregation technique introduced by Yildiran [2009] to study the convex hull of regions defined by two quadratic or by a conic quadratic and a quadratic inequality. Yildiran shows how to characterize the convex hull of sets defined by two quadratics using Linear Matrix Inequalities (LMI). We show how this aggregation technique can be easily extended to yield valid conic quadratic inequalities for the convex hull of sets defined by two quadratic or by a conic quadratic and a quadratic inequality. We also show that in many cases, these valid inequalities characterize the convex hull exactly.

3 - Learning in Combinatorial Optimization: How and What to Explore

Denis Saure, Universidad de Chile, Republica 701, Santiago, Chile,
dsaure@dii.uchile.cl, Sajad Modaresi, Juan Pablo Vielma

We study sequential combinatorial optimization under model uncertainty. We show that for balancing the implied exploration vs exploitation trade-off it is critical to resolve the issue of what information to collect and how to do so. Our answer to these questions lies in solving an adjunct formulation, which looks for the cheapest solution-based optimality guarantee. We develop fundamental limit on performance, and develop an efficient policy implementable in real-time.

■ FD29

29- Commonwealth 1

MINLP: Theory and Applications

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Carsten Schaefer, TU Darmstadt, Dolivostrafle 15, Darmstadt, 64293, Germany, cschaefer@mathematik.tu-darmstadt.de

1 - Optimal Actuator Placement for Dynamical Systems

Carsten Schaefer, TU Darmstadt, Dolivostrafle 15, Darmstadt,
64293, Germany, cschaefer@mathematik.tu-darmstadt.de,
Stefan Ulbrich

Vibrations occur in many areas of industry and produce undesirable side effects. To avoid or suppress these effects, actuators are attached to the structure. The appropriate positioning of actuators is of significant importance for the controllability of the structure. Using controllability measures, a method for determining the optimal actuator placement is presented, which leads to an optimization problem with binary and continuous variables and linear matrix inequalities. Numerical results show the optimal actuator placement for a truss structure.

2 - On a Novel Versatile Trust-Tech Based Methodology for Nonlinear Integer Programming

Hsiao-Dong Chiang, Professor, School of Electrical and Computer
Engineering, 328 Rhodes Hall, Cornell University, Ithaca, NY,
14853, United States of America, chiang@ece.cornell.edu,
Tao Wang

We propose a new methodology to guide numerical methods and solvers for nonlinear integer programming and improve the solution quality by adopting the Transformation Under Stability-reTraining Equilibrium Characterization (Trust-Tech) method. The effectiveness is examined by simulating the popular and state-of-the-art methods/solvers (Branch-and-Bound, GAMS/BARON, GAMS/SCIP, LINDO/MINLP, EA-based methods) and those guided by the proposed methodology. Simulation results show that global search capability, solution quality and consistency are considerably improved, and the global-optimal solutions are usually obtained, after applying the methodology. When properly integrated, it also can lead to substantial reduction of computing time.

3 - Error Bounds for Nonlinear Granular Optimization Problems

Oliver Stein, Karlsruhe Institute of Technology (KIT), Institute of
Operations Research, Kaiserstr. 12, Karlsruhe, 76131, Germany,
stein@kit.edu

We study a-priori and a-posteriori error bounds for optimality and feasibility of a point generated as the rounding of an optimal point of the relaxation of a mixed integer convex optimization problem. Treating the mesh size of integer vectors as a parameter allows us to study the effect of different `granularities' in the discrete variables on the error bounds. Our analysis mainly bases on the construction of a so-called grid relaxation retract. Relations to proximity results and the integer rounding property in the linear case are highlighted.

■ FD30

30- Commonwealth 2

Approximation and Online Algorithms XIV

Cluster: Approximation and Online Algorithms

Invited Session

Chair: R. Ravi, Professor, Tepper School of Business - Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213, United States of America, ravi@cmu.edu

1 - The a Priori Traveling Repairman Problem

Martijn van Ee, PhD Student, VU University Amsterdam,
De Boelelaan 1105, Amsterdam, 1081 HV, Netherlands,
m.van.ee@vu.nl, René Sitters

The field of a priori optimization is an interesting subfield of stochastic combinatorial optimization that is well suited for routing problems. In this setting, one has to construct a tour in the first stage and there is a probability distribution over active sets, which are vertices to be visited in the second stage. For a fixed first-stage tour, the second-stage tour on an active set is obtained by restricting the tour to this set. In the a priori traveling repairman problem, the goal is to find a tour that minimizes the expected sum of latencies of the second-stage tour. The latency of a vertex is the distance traveled from the root to the vertex along the tour. Here, we present the first constant factor approximation for this problem.

2 - Improved Approximations for Cubic and Cubic Bipartite Graph-TSP

Anke van Zuylen, College of William and Mary, 200 Ukrop Way, Mathematics Department, Williamsburg, VA, 23185, United States of America, anke@wm.edu

We show improved approximation guarantees for the traveling salesman problem on graph metrics where the graph is cubic or cubic and bipartite. For cubic bipartite graphs with n nodes, we improve on recent results of Karp and Ravi (2014) by giving a much simpler algorithm that finds a tour of length at most $5/4n-2$. For cubic graphs, we show that the techniques of M\"omke and Svensson (2011) can be combined with the techniques of Correa, Larr\'e and Soto (2012), to obtain a tour of length at most $(4/3-1/8754)n$.

3 - Improved Approximations for Graph-TSP in Regular Graphs

R. Ravi, Professor, Tepper School of Business - Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213, United States of America, ravi@cmu.edu, Alantha Newman, Satoru Iwata, Jeremy Karp

A tour in a graph is a connected walk that visits every vertex at least once, and returns to the starting vertex. We give improved approximation results for a tour with the minimum number of edges in regular graphs.

Friday, 4:35pm - 5:25pm

■ FE01

01- Grand 1

Mathematical Optimization for Packing Problems

Cluster: Plenary

Invited Session

Chair: R. Ravi, Professor, Tepper School of Business - Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213, United States of America, ravi@cmu.edu

1 - Mathematical Optimization for Packing Problems

Frank Vallentin, University of Koeln, Koehn, Germany, frank.vallentin@uni-koeln.de

How densely can one pack given objects into a given container? Such packing problems are fundamental problems in geometric optimization. Next to being classical mathematical challenges there are many applications in diverse areas such as information theory, materials science, physics, logistics, approximation theory. Studying packing problems one is facing two basic tasks: Constructions: How to construct packings which are conjecturally optimal? Obstructions: How to prove that a given packing is indeed optimal? For the first basic task researchers in mathematics and engineering found many heuristics which often work well in practice. In the talk I want explain computational tools for the second basic task. These tools are a blend of tools coming from infinite-dimensional semidefinite optimization and harmonic analysis, together with computational techniques coming from real algebraic geometry and polynomial optimization. I will report on computational results, which are frequently the best-known.

■ FE02

02- Grand 2

Recent Advances in Trust-Region Algorithms

Cluster: Plenary

Invited Session

Chair: Xiaojun Chen, Professor, The Hong Kong Polytechnic University, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, xiaojun.chen@polyu.edu.hk

1 - Recent Advances in Trust-Region Algorithms

Ya-xiang Yuan, Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Zhong Guan Cun Donglu 55, Haidian, Beijing, 100190, China, yyx@lsec.cc.ac.cn

Trust-region methods are a class of numerical methods for optimization. Unlike line search type methods where a line search is carried out in each iteration, trust-region methods compute a trial step by solving a trust-region subproblem where a model function is minimized within a trust region. Due to the trust-region constraint, nonconvex models can be used in trust-region subproblems, and trust-region algorithms can be applied to nonconvex and ill-conditioned problems. Normally it is easier to establish the global convergence of a trust-region algorithm than that of its line search counterpart. In the paper, we review recent results on trust-region methods for unconstrained optimization, constrained optimization, nonlinear equations and nonlinear least squares, nonsmooth optimization and optimization without derivatives. Results on trust-region subproblems and regularization methods are also discussed.

Session Chair Index

N

O

P

R

S

T

U

V

W

X

Y

Z

Author Index

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

T

Z

Session Index

Monday, 9:00am - 9:50am

Monday, 10:20am - 11:50am

Monday, 1:10pm - 2:40pm

Monday, 2:45pm - 4:15pm

Monday 4:35pm - 5:25pm

Monday, 5:30pm - 7:00pm

Tuesday, 9:00am - 9:50am

Tuesday, 10:20am - 11:50am

Tuesday, 1:10pm - 2:40pm

Tuesday, 2:45pm - 4:15pm

Tuesday, 4:35pm - 5:25pm

Wednesday, 9:00am - 9:50am

Wednesday, 10:20am - 11:50am

Wednesday, 1:10pm - 2:40pm

Wednesday, 2:45pm - 4:15pm

Wednesday 4:35pm - 5:25pm

Wednesday 5:30pm - 6:20pm

Thursday, 9:00am - 9:50am

Thursday, 10:20am - 11:50am

Thursday, 1:10pm - 2:40pm

Thursday, 2:45pm - 4:15pm

Thursday, 4:35pm - 5:25pm

Thursday, 5:30pm - 7:00pm

Friday, 9:00am - 9:50am

Friday, 10:20am - 11:50am

Friday, 1:10pm - 2:40pm

Friday, 2:45pm - 4:15pm

Friday, 4:35pm - 5:25pm