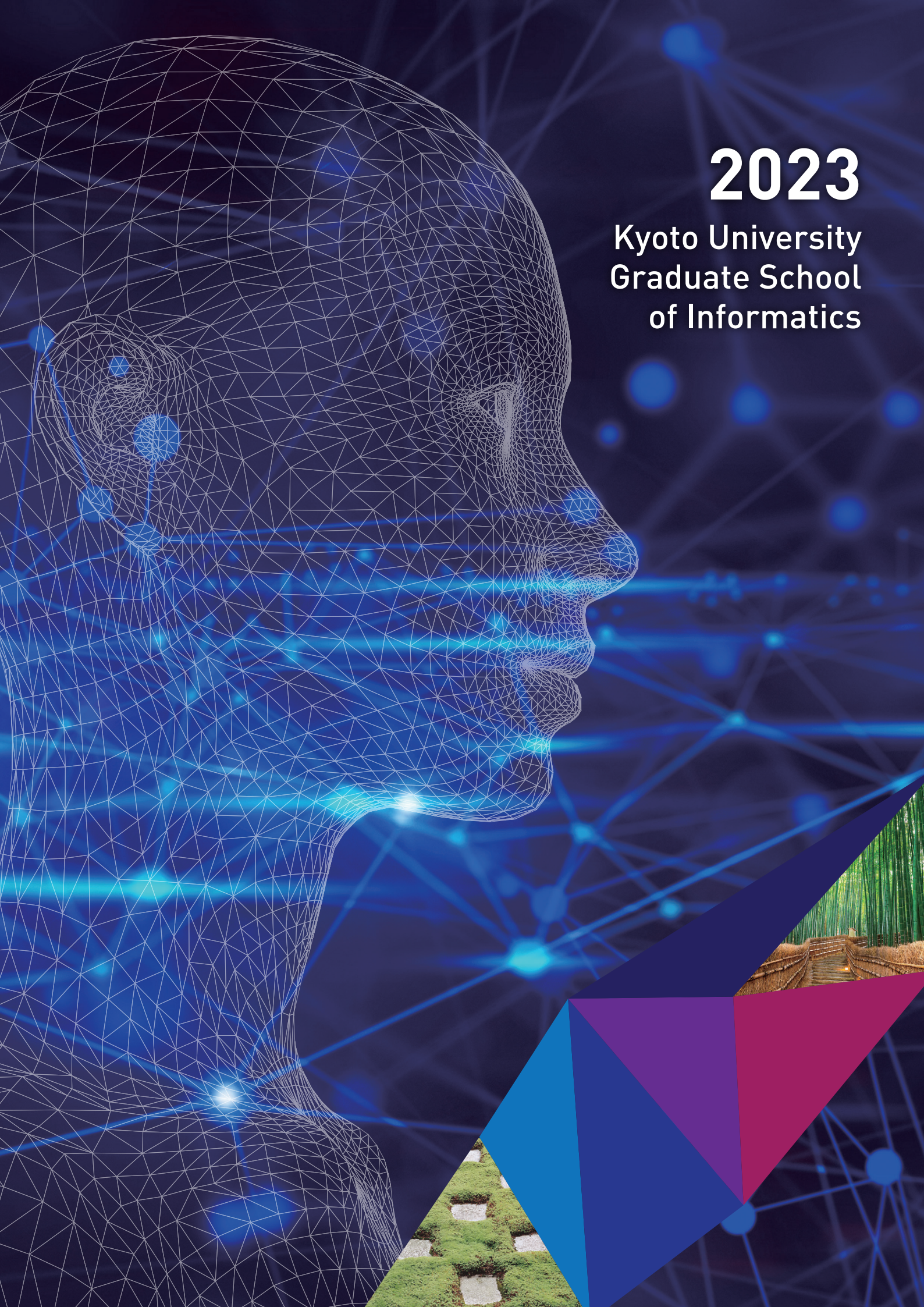
2023

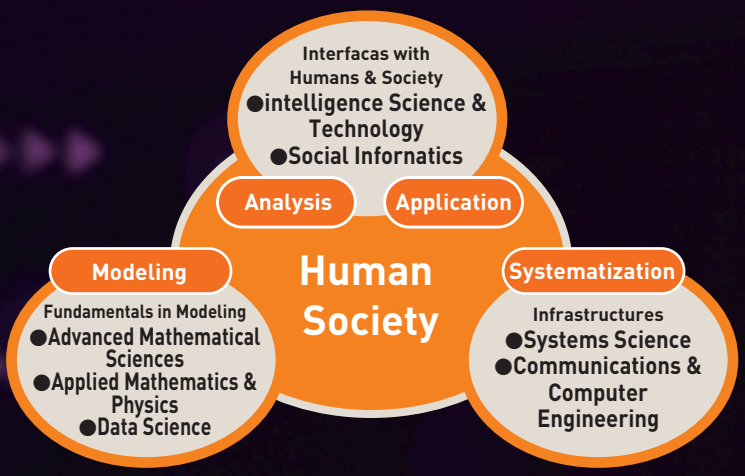
Kyoto University Graduate School of Informatics



Kyoto University, Graduate School of Informatics

From Kyoto to the world.

Informatics is a cutting-edge interdisciplinary field for the 21st century which assimilates information with humans and society.



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List of Departments, Divisions and Groups
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Definition of Informatics

Informatics in Kyoto University is the study of information in natural and artificial systems.

Informatics studies the creation, recognition, representation, collection, organization, optimization, transformation, communication, evaluation and control of information in complex and dynamic systems.

Informatics has human, social, cognitive, biological, linguistic, computational, mathematical and engineering aspects. It includes systems science and communications engineering.

Informatics has close relations with a number of disciplines in the natural and human sciences. It is developed employing contributions from many different areas : in turn, it can contribute to their further development.

Interfaces to human and social areas, mathematical modeling and information systems are the three pillars of Informatics in Kyoto University.

Welcome to Graduate School of Informatics

Kyoto University Graduate School of Informatics, which was the first graduate school in Japan to use the term "informatics" in its name when it was established in April 1998, recently celebrated the 25th anniversary of its founding. Here, I would like to offer an overview of the research fields and educational programs of Graduate School of Informatics and outline some of its outstanding features.

Dean, Graduate School of Informatics

Atsushi Igarashi

What is Informatics?

The preceding section of this booklet includes a definition of informatics as envisioned by this graduate school. It states that "informatics in Kyoto University is the study of information in natural and artificial systems," that "informatics has human, social, cognitive, biological, linguistic, computational, mathematical, and engineering aspects ... and includes systems science and communications engineering," and that it "has close relations with a number of disciplines in the natural and human sciences." The term "information" tends to highlight computer-based technologies, such as information and communication technologies (ICT) and artificial intelligence (AI), but our definition of informatics points to an academic discipline that is far more interdisciplinary than these technologies suggest.

As mentioned, our graduate school was the first in Japan to define itself using the term "informatics." Up to that time, most schools and departments in Japan in this general field used names containing "computer science/engineering" or "information science," but between the late 1990s and early 2000s, Kyoto University and some other leading universities, including Hokkaido University, Tohoku University, The University of Tokyo, Tokyo Institute of Technology, Nagoya University, Osaka University, and Kyushu University established graduate schools in information-related science, typically with names like "Graduate School of Information Science/Engineering" or "Graduate School of Information Science." Only Kyoto University adopted the broader term "informatics." In fact, two years before Graduate School of Informatics was established, the "School of Informatics and Mathematical Science" was created in the Faculty of Engineering through a merger of the School of Information Science and the School of Applied Mathematics and Physics. The use of "informatics" was very unusual at the time. These name choices were motivated by the desire of the people involved in setting up this graduate school to establish a broader discipline of "informatics" to transcend the limits of the conventional disciplines of "information science/engineering" or "information science."

I imagine that all the students who apply to this graduate school are keen to study their chosen field of specialization seriously. As they steadfastly pursue their desire, I hope that they also take the time to look around to survey the whole of the graduate school and experience the full breadth of "informatics." As explained below, the educational program is designed to allow students to experience a wide range of this rich and broad field.

Education and Research in Graduate School of Informatics

Graduate School of Informatics is one of the largest graduate schools at Kyoto University, with a current intake (per academic year) of 240 students for the Master's program and 60 students for the Doctoral program. The graduate school consists of seven "courses" of study under the "major" of informatics.

- Intelligence Science and Technology Course
- Social Informatics Course
- Advanced Mathematical Sciences Course
- Applied Mathematics and Physics Course
- Systems Science Course
- Communications and Computer Engineering Course
- Data Science Course

Each course is taught not only by faculty from within the Graduate School of Informatics, but also by faculty (as cooperating professors) from other departments within the university, such as the Academic Center for Computing and Media Studies, Disaster Prevention Research Institute, Kyoto University Hospital, Institute for Chemical Research, Research Institute for Sustainable Humanosphere, and Institute for Liberal Arts and Sciences, as well as by collaborating researchers from institutions outside the university, including RIKEN, NTT, Hitachi, Advanced Telecommunications Research Institute International (ATR), and Okinawa Institute of Science and Technology (OIST). The research fields (labs) of each course are described in the introduction to each course below. The names of these courses alone indicate the remarkable breadth of study and research covered by Graduate School of Informatics. Leading-edge informatics research is conducted in all these fields.

A key feature of the curricula of our graduate school is that it is designed not only to allow students to study the primary academic major of their choice, but also to equip them with a broad range of knowledge that transcends the boundaries of their chosen field of specialization. One example is the inter-departmental course "Perspectives in Informatics," required electives for the Master's program. In the Doctoral program, students naturally cultivate a deeper knowledge of their field of specialization through the research guidance of their academic advisors, but they also acquire a comprehensive academic vision through seminar subjects in each course.

As part of its efforts to internationalize education, the school offers a number of courses in English. These are taught by both Japanese and non-Japanese faculty. In some courses, we even enable students to earn a Master's degree without learning Japanese, by offering classes and research guidance in English ("International Program"). In the case of Doctoral programs, students can pursue their research and earn a PhD in any of the courses without the need to learn Japanese. Even Japanese students (who are not international students) can choose to take the International Program if it is offered for the course they are pursuing. On successful completion, such students are awarded an "International Program Completion Certificate" along with their degree.

Graduate School of Informatics also takes part in five-year doctoral programs offered by multiple Kyoto University graduate schools in collaboration with companies, overseas universities, research institutes, and other external organizations. These are the Kyoto University School of Platforms and Kyoto University Collaborative Graduate Program in Design, run by the Center for the Promotion of Excellence in Higher Education (CPEHE). Students in Graduate School of Informatics can take advantage of these programs to earn a degree. For additional information, see a more detailed outline or access applicable website URLs of these programs below (in this booklet).

It is not an overstatement to say that graduates of this school who have received this kind of advanced education are becoming increasingly sought after for a variety of roles as the field of informatics expands. Such graduates typically find work as researchers in universities or corporate research labs, and as expert engineers in a wide range of industries, including ICT, manufacturing, finance, broadcasting, and services.

Our Reorganization

In April 2023, on the 25th anniversary of its establishment, Kyoto University Graduate School of Informatics was reorganized. The six existing departments (Intelligence Science and Technology, Social Informatics, Advanced Mathematical Sciences, Applied Mathematics and Physics, Systems Science, and Communications and Computer Engineering) were merged into a single Department of Informatics. The educational programs of the previous six departments were transformed into "courses" and a new "Data Science Course" was added (making a total of seven courses). At the same time, the total student intake for the Master's program was increased (from 189 to 240 students per academic year).

The main purposes of the reorganization were to respond to the sharp rise in the number of students wishing to study informatics in recent years, as well as to cultivate experts in the increasingly important field of data science, which is closely connected to informatics. Creating multiple educational courses under a single major (field of specialization) also allows the school to establish and deliver more flexible educational programs. In fact, education in the new Data Science Course will be provided both by faculty who work primarily in Graduate School of Informatics and faculty from the Center for Innovative Research and Education in Data Science of the Kyoto University Institute for Liberal Arts and Sciences, who will concurrently serve in Graduate School of Informatics. Structuring the educational program in this way would have been difficult under a conventional framework of majors. We regard this reduction to a single major as an important initiative for enabling us to provide education that is better attuned to the anticipated changes and developments in informatics over the coming years.

Concluding Remarks

This brief overview of Graduate School of Informatics is focused on educational programs. Of course, a wide variety of research in informatics is also conducted within the school. The presentations of the labs in each of the courses offer a glimpse of these research activities. Graduate School of Informatics also places great importance on pure research. Without a deep knowledge of the fundamentals, it is not possible to create robust technologies that can remain useful for many years. Informatics as a field of study is still in its nascent phase. Given the youthfulness of this field, it seems very fitting to pursue research in informatics at Kyoto University, in a city where tradition and innovation have coexisted for many centuries. We look forward to seeing students take up exciting challenges under this new structure.

Atsushi Igarashi

Dean, Graduate School of Informatics

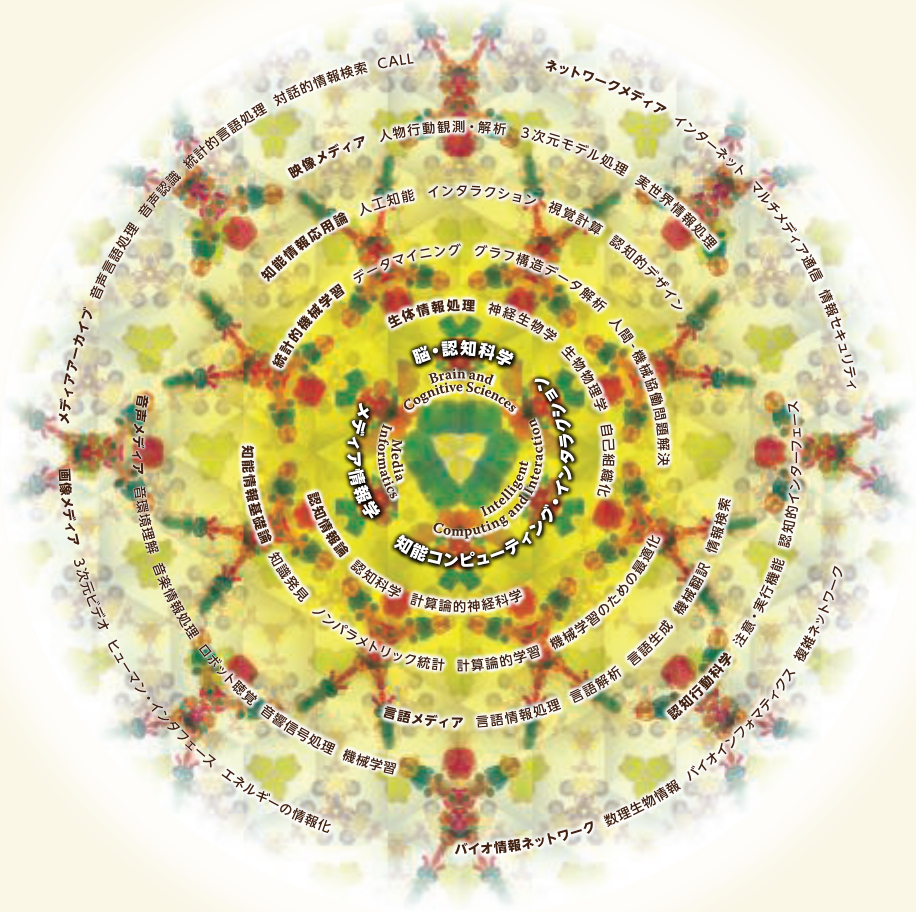
Atsushi Igarashi is a Professor at Graduate School of Informatics, Kyoto University. He received his B.S., M.S., and D.S. degrees from Department of Information Science, University of Tokyo in 1995, 1997, and 2000, respectively. Formerly, he belonged to Dept. of Graphics and Computer Science, Graduate School of Arts and Sciences, University of Tokyo. His major research interests are in theoretical computer science, in particular, principles of programming languages and program verification. He has been awarded a few domestic and international academic prizes, including the AITO Dahl-Nygaard Junior Prize for his investigations into the foundation of object-oriented programming languages and their type systems.

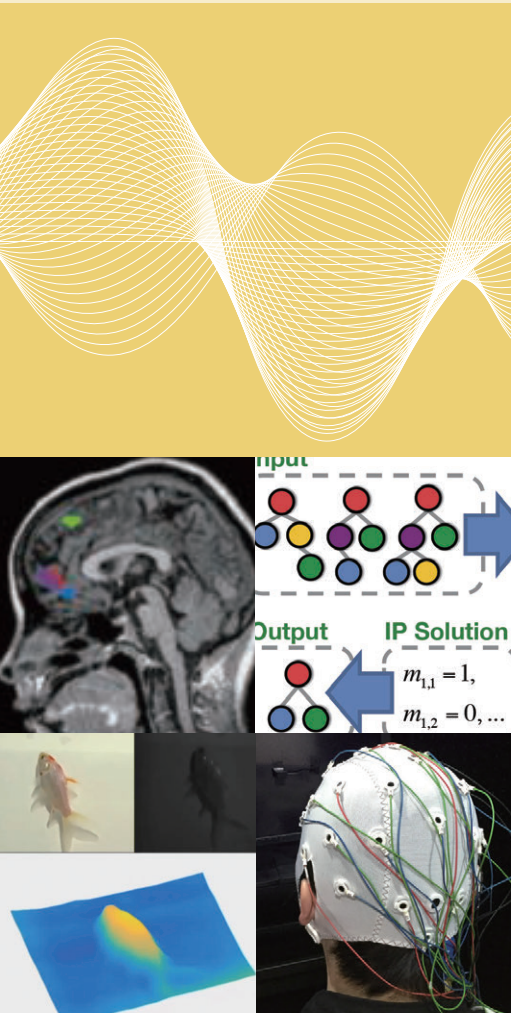
Courses in Graduate School of Informatics


Applied Mathematics and Physics Course
Applied Mathematical Analysis
Discrete Mathematics
System Optimization
Control Systems Theory
Physical Statistics
Dynamical Systems
Applied Mathematical Modeling (Adjunct Unit)
Communications and Computer Engineering Course
Computer Algorithms
Computer Architecture
Computer Software
Digital Communications
Integrated-Media Communications
Intelligent Communication Networks
Processor Architecture and Systems Synthesis
Integrated Circuits Design Engineering
Advanced Signal Processing
Remote Sensing Engineering
Atmospheric Observations
Supercomputing
Multimedia and Secure Networking
Systems Science Course
Mechanical Systems Control
Human Systems
Integrated Dynamical Systems
Mathematical Information Systems
Statistical Intelligence
Learning Machines
Integrated Systems Biology
Biomedical Engineering
Computational Neuroscience (Adjunct Unit)
Data Science Course
Statistical Mathematics
Statistical Inference
Information-Theoretic Learning
Signal and Information Processing
Applied Machine Learning
Medical and Healthcare Data Science
Computational Intelligence Systems (Adjunct Unit)

Construction and Elucidation of Intelligence, and Realization of Flexible, Human-like Information Processing.

In an advanced information-oriented society, information processing with flexible, human-like information capabilities becomes essential. Information processing in human and animal organic systems is unparalleled in nature which has developed through structural and functional adaptation to the environment in the long process of evolution. Intelligence Science and Technology is a multidisciplinary field that aims to elucidate the mechanisms of biological-, particularly, human-information processing for the development of higher-level information processing.





Welcome to Intelligence Science and Technology Course

Intelligence Science and Technology is an interdisciplinary research field in which we study sophisticated human information processing and develop new technologies on the basis of an understanding of human intelligence. By "intelligence," we do not mean simply "artificial intelligence" but rather a wider scope embracing intelligent aspects of human, systems, and information technology. More specifically, foci of our research and educational activities include (i) basic mechanisms of human beings, such as life, brain, cognition, and behavior, (ii) information media related to language, speech/auditory, and visual information, and (iii) a broad range of topics related to intelligence and informatics, such as interaction between human and intelligent systems, artificial intelligence and machine learning, and software and networks.

One of our distinguishing features is integration of these topics under a unique discipline, "intelligence science and technology," notwithstanding that these topics are also investigated in separate research fields such as neuroscience, psychology, engineering, and computer science. Faculty members and students coming from a wide variety of academic backgrounds devote themselves to cooperating in pursuit of this common goal. We hope that, in this unique academic environment, many young students will engage in this exciting research field, tackle the mysteries of complex human intelligence, and develop new ideas for addressing challenging issues regarding intelligent media and computation.

Our course welcomes outstanding students from various fields besides those of computer science and engineering. We provide interdisciplinary curricula and research projects. Join us, and enjoy an intellectually exciting experience!

Shin'ya Nishida

Professor, Intelligence Science and Technology Course

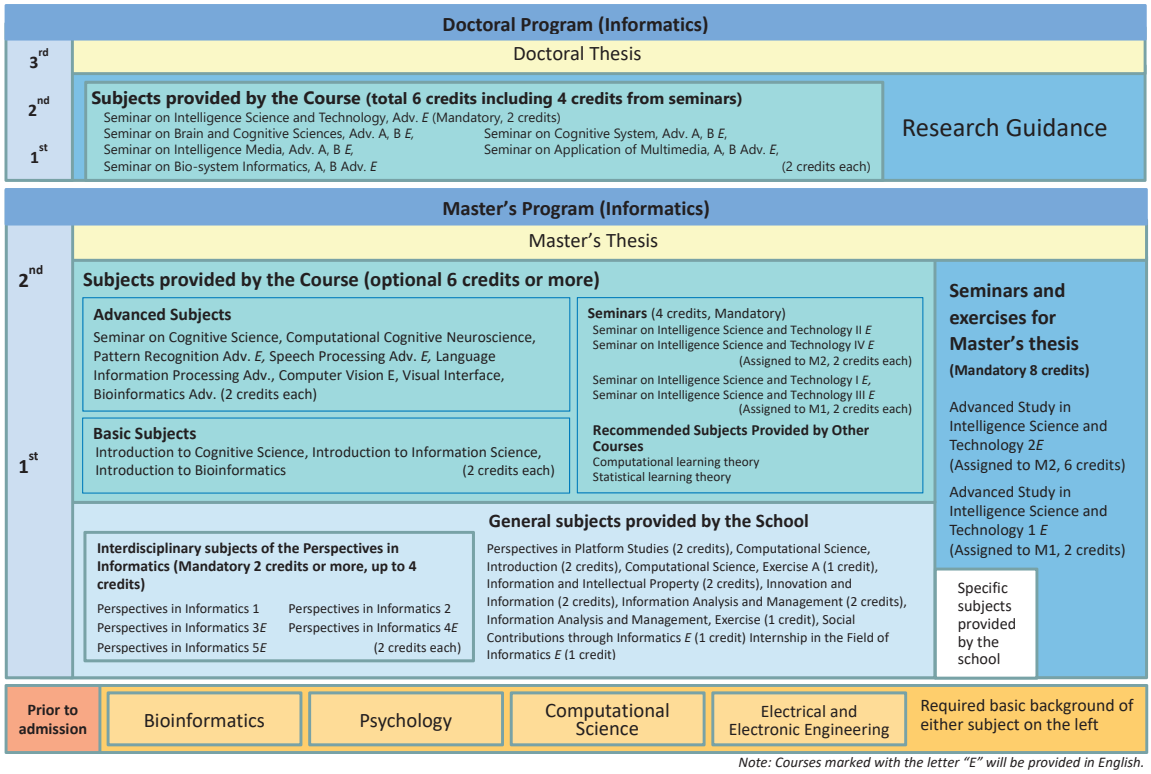
1990 Research Associate, ATR Auditory and Visual Perception Laboratories
1992 Research Scientist, NTT Basic Research Laboratories
1996 Ph.D., Kyoto University
1999 Research Scientist, NTT Communication Science Laboratories
2019 Professor, Kyoto University

Outline

Group and Teaching Staff

Group	Teaching Staff
Neuroinformatics	Yukiyasu Kamitani/Professor Yukiori Goto/Associate Professor Hiroshi Hosokawa/Senior Lecturer Yoshihiro Nagano/Assistant Professor Shingo Maegawa/Assistant Professor
Psychoinformatics	Takatsune Kumada/Professor Ryoichi Nakashima/Associate Professor
Cognitive Informatics	Shin'ya Nishida/Professor Hiroaki Mizuhara/Associate Professor Kiyofumi Miyoshi/Assistant Professor
Computational Cognitive Neuroscience (Adjunct Unit)	Hiroyuki Nakahara/Adjunct Professor Wataru Sato/Adjunct Associate Professor(RIKEN)
Computational Intelligence	Akihiro Yamamoto/Professor Nozomi Akashi/Assistant Professor
Collective Intelligence	Hisashi Kashima/Professor Koh Takeuchi/Assistant Professor Han Bao/Program-Specific
Conversational Informatics	
Language Media Processing	Sadao Kurohashi/Program-Specific Professor Yugo Murawaki/Senior Lecturer Chenhui Chu/Program-Specific Associate Professor Fei Cheng/Program-Specific Assistant Professor Yin Jou Huang/Program-Specific Assistant Professor
Speech and Audio Processing	Tatsuya Kawahara/Professor Kazuyoshi Yoshii/Associate Professor Koji Inoue/Assistant Professor Keiko Ochi/Program-Specific Assistant Professor Eita Nakamura/Program-Specific Assistant Professor
Computer Vision	Ko Nishino/Professor Shohei Nobuhara/Associate Professor Marc Aurel Kastner/Assistant Professor
Human Sensing	Yuichi Nakamura/Professor Kazuaki Kondo /Associate Professor Kei Shimonishi/Assistant Professor
Text Media	Shinsuke Mori/Professor Hirotaka Kameko/Assistant Professor
Biological Information Networks	Tatsuya Akutsu/Professor Takeyuki Tamura/Associate Professor Tomoya Mori/Assistant Professor

Curriculum of Intelligence Science and Technology Course

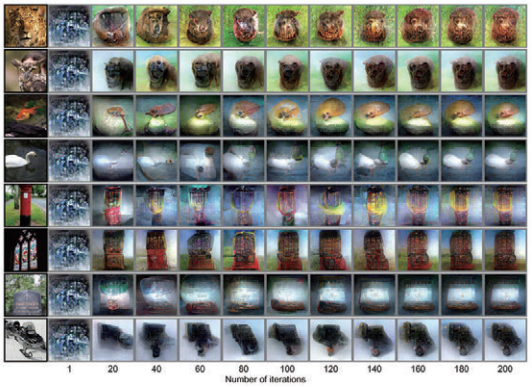


Note: Courses marked with the letter "E" will be provided in English.

Brain and Cognitive Sciences

Decoding neural codes

Brain signals can be seen as "codes" that encode our mental contents. We study methods for modeling brain functions and representations using information science and technology including machine learning and artificial neural networks. Our approach is based on data-driven predictive models that relate brain data and mind states via analysis of massive neural, behavioral, and multimedia data. Using these models, we aim to understand basic principles of neural information processing, and seek to develop real-life applications such as brain–machine interfaces that exploit decoded brain information.



[Yukiyasu Kamitani , Yukiori Goto , Hiroshi Hosokawa , Shingo Maegawa , Yoshihiro Nagano]

Psychoinformatics

Toward understanding human cognition and applying it to human-machine interface

Human activities in daily life are supported by basic cognitive functions, such as perception, attention, memory and high-order executive control. We investigate the psychological and neuroscientific bases of these cognitive functions (especially focusing on attention and executive function), using psychological experiments, brain-imaging and computational techniques. We are interested in human behavior not only in well-controlled experimental settings in a laboratory, but also in real-world settings such as IT-equipment use and real car driving. We are also interested in cognitive functions in a wide range of populations, from healthy young adults to older or disabled individuals.

An experiment examining eye and action coordination

[Takatsune Kumada , Ryoichi Nakashima]

Outline

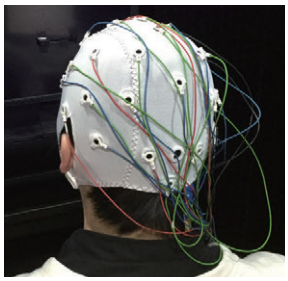
Cognitive Informatics

Understanding Human Sensory and Cognitive Information Processing

Our lab studies the computational principle and the neural mechanisms of human functions including perception, cognition and language processing, by means of psychophysics, computer simulations and EEG recordings. By comparing human brains with cutting-edge artificial intelligent systems, we attempt to reveal the characteristic nature of the human information processing. We are also interested in leveraging human scientific studies for innovation of information technologies.

[Shin'ya Nishida , Hiroaki Mizuhara , Kiyofumi Miyoshi]

Material perception is one of our research topics.



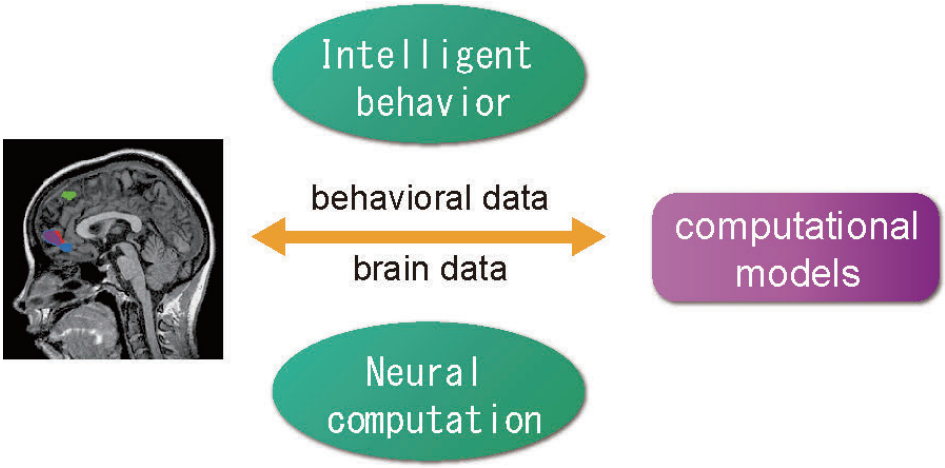
Brain researches by EEG measurements

Computational Cognitive Neuroscience (Adjunct Unit)

Neural information processing and computational models

We aim to understand the computational principles that underlie the way neural systems realize adaptive behavior and complex minds: e.g., decision-making, reinforcement learning, motivation and emotion, and social behaviors. Our approaches are tightly linked to statistical and information science including machine learning and neural networks, as well as to questions in neuroscience and psychology. To address our questions, we build computational and mathematical models, and develop data analysis methods for linking those behavioral functions and brain signals through computations. We use human fMRI to examine neural signals and computations, combined with those modeling and quantitative methods. We also seek to use our insights to be applied to constructing brain-based intelligence.

[RIKEN: Hiroyuki Nakahara , Wataru Sato]

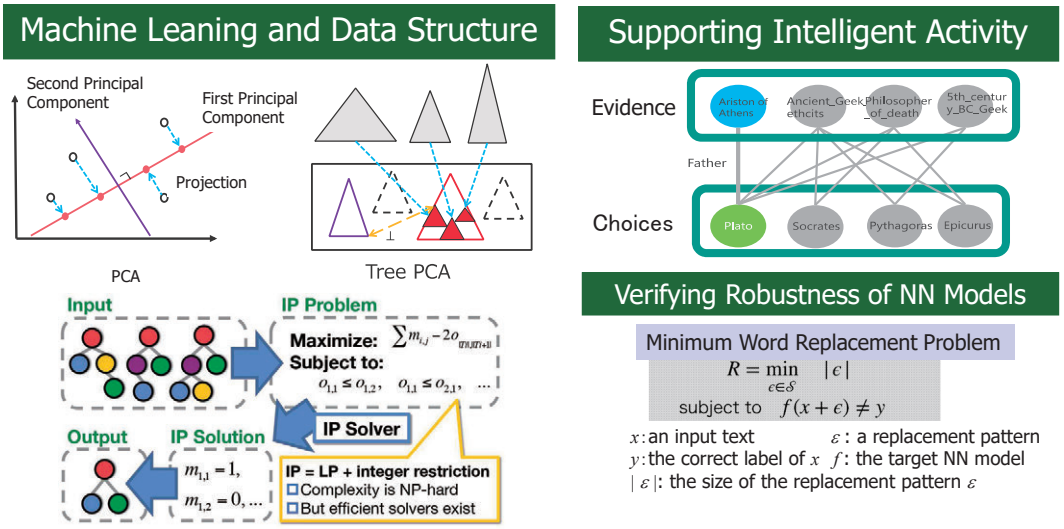


Computational Intelligence

Formulation of principles to support intelligent information processing

We will formalize the intelligent information processing seen in human activities and conduct studies on the basic principles that underlie these processes, as well as realization methods. Specifically, this will involve education and research relating to artificial intelligence information processing such as inductive logic, knowledge discovery, hypothetical reasoning, and evolvable computers, using mathematical logic, inference procedures, machine learning theories and self-organization.

[Akihiro Yamamoto , Nozomi Akashi]

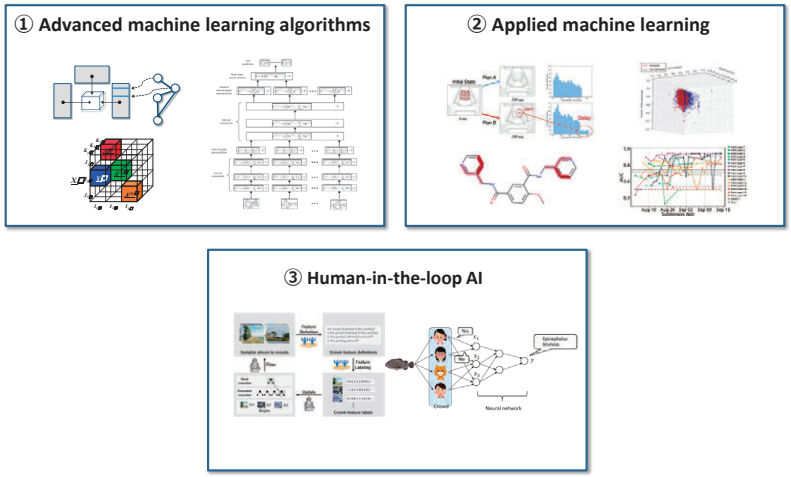


Collective Intelligence

Machine Learning That Matters

Our research focus is on the development of fundamental technologies for intelligent information technology, with a focus on machine learning, and their real-world applications. While pursuing R&D on new problems and methods of machine learning and data analysis, we also tackle various challenges in science and business. At the same time, we conduct research on methodologies for solving challenging problems that are difficult to address by AI or humans alone, by combining AI with human power.

[Hisashi Kashima , Koh Takeuchi , Han Bao]

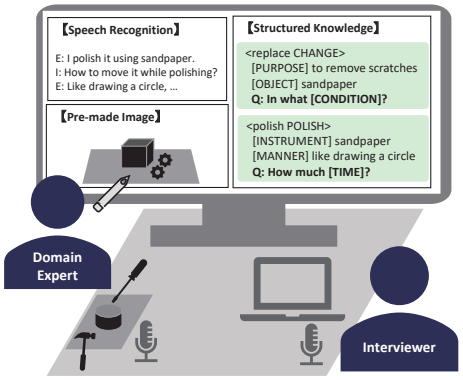


Outline

Language Media Processing

Making computers that can understand language

Since language lies at the core of human intellectual activity, the emergence of computers capable of freely manipulating language will significantly impact society in a broad variety of ways. With this goal, we are engaged in research to shed light on how humans utilize language and to enable computers to communicate using language in human-like ways. We are pursuing both pure research on language understanding based on large-scale language models and applied research for useful real-world purposes, such as translation, dialogue, and knowledge structuring.

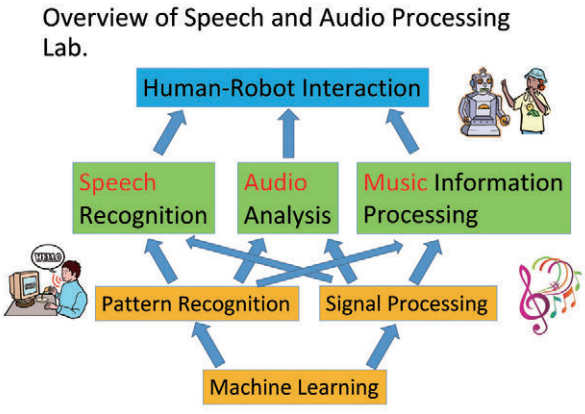


[Sadao Kurohashi , Yugo Murawaki , Chenhui Chu , Fei Cheng , Yin Jou Huang]

Speech and Audio Processing

Recognition and understanding of speech, audio and music

Speech communication plays a key role in human intelligence. We are studying the intelligent processing of speech, audio and music as exchanged by human beings for automatic recognition, understanding and interaction systems, specifically (1) automatic speech transcription of meetings and lectures, (2) analysis of audio scenes and music signals composed of multiple sound sources, and (3) humanoid robots capable of natural interaction by combining non-verbal information.



[Tatsuya Kawahara , Kazuyoshi Yoshii , Koji Inoue , Keiko Ochi , Eita Nakamura]

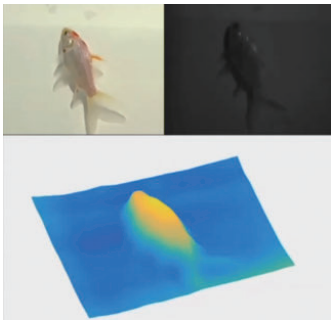
Computer Vision

Making Computers See

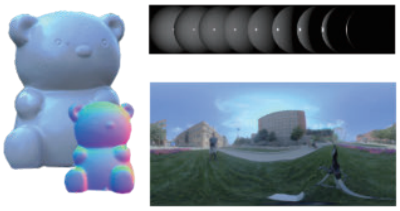
Neural substrates dedicated to vision are said to occupy about 40 percent of the cerebral cortex. Realizing computer vision as a truly intelligent perceptual modality is fundamental for artificial intelligence, and would also inform our understanding of human visual intelligence. Towards computational visual intelligence, our research is focused on establishing the theoretical foundations and efficient implementations of computational methods for better understanding people, objects and scenes from their appearance in images and video, as well as the development of novel computational imaging systems that can see beyond what we see.

[Ko Nishino , Shohei Nobuhara , Marc Aurel Kastner]

Tracking People in Crowds



Shape from Water



Reflectance and Natural Illumination from a Single Image

Outline

Human Sensing

Toward human-centered information and machine systems through visual and embodied interactions

The main purpose of this group is to create information media and mechanical systems that support human with respecting their subjective actions.

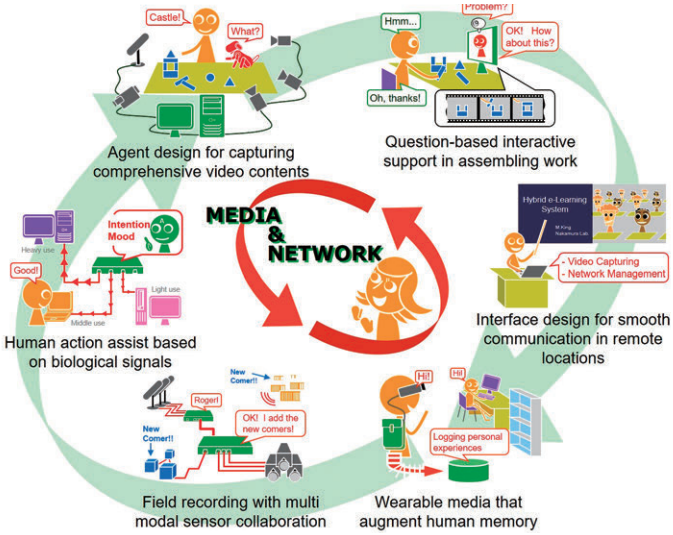
Such media include watching over humans to provide supports in appropriate way and time, supplying only deficient force in motions, interfaces that connects humans and computers, and assisting human memory.

A common approach in all of these media is that information or mechanical systems notice human's intention and augment their abilities for meeting what they want to do.

To realize this support scheme, this group is engaged in basic researches involving (1) artificial intelligence and knowledge processing, (2) recognition of human physical and physiological activities using visual, acoustic, and biological measurements, (3) modeling human behaviors in motion and communication, while (4) designing and implementing the human-centered supporting media using (5) robotic and artificial agent control technology.

- Interface of visualizing human intentions inferred from motions
- Wearable computers for recording and supporting personal/group experiences
- Motion assist based on behavioral analysis using electromyography
- Facial expression recognition for health science and care of dementia persons
- Joint research using image analysis and AI with other laboratories and research centers within and outside of Kyoto University

[Yuichi Nakamura , Kazuaki Kondo, Kei Shimonishi]



Text Media

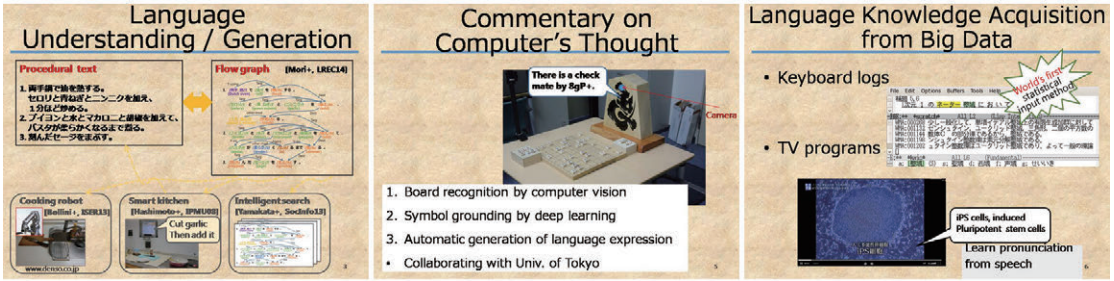
Speech and Natural Language Processing for Multi-media Archives

Since time immemorial human knowledge has been recorded as text. The research activities of this group focus on computers capable of understanding these texts and describing new knowledge. As a basis we are studying fundamental natural language processing. And we are studying natural language generation to explain data analysis and future prediction by computer or to describe other media such as video and speech.

Specifically, we deal with real-world media, including procedural texts such as cooking recipes with execution videos, academic knowledge such as history/geography research, and game/data analysis by computers.

We also try to expand human knowledge based on our research results.

[Shinsuke Mori , Hirotaka Kameko]

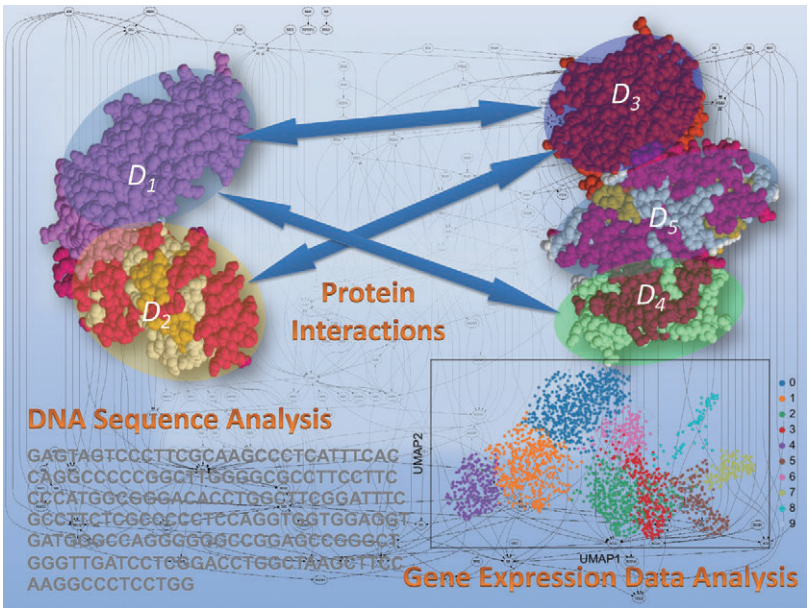


Biological Information Networks

It for analysis of biological information

We develop algorithms for inferring interactions among genes, proteins and chemical structures, and for analyzing their interactive networks based on mathematical methods. We also develop algorithms and software tools for other problems in bioinformatics, including sequence analysis and inference of higher-order structures and functions of protein.

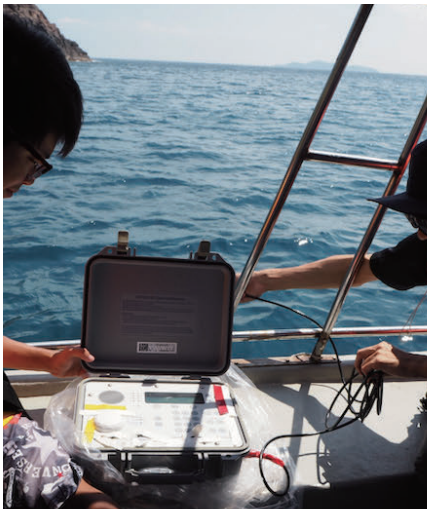
[Tatsuya Akutsu , Takeyuki Tamura , Tomoya Mori]



Analysis of three-dimensional structures and interactions of protein

Harmonizing Society and Information Technology

Global networking is rapidly expanding via information technology.
Based upon the trends of technologies that interact with our daily lives, Social Informatics Course seeks to clarify the structures of highly complex information societies and actually design information systems that are globally useful.
Therefore, we endeavor to support globalizing activities in the areas of culture, economics, ecology, disaster management, healthcare and education.



Information is Born in the Lives of People

Sources of social information do not exist on the Internet.

These sources are usually found in people's daily lives. Social informatics includes processes from the acquisition of information from the sources, through constructing systems to utilize the information, to designing a better society using those information systems. For example, we collect ecological information relevant to fish by using bio-logging techniques for fishery resource conservation. We also glean biological information from forest ecosystems using various types of sensors to optimize the sustainable utilization of ecosystem services. Then, we study methods for database development to organize that information on natural resources and environments. Moreover, we study informatics applications in the fields of medical services and education, and also determine what types of information are needed for disaster prevention and harm minimization. We consider ways to utilize the data to design societies and social systems. We, the people in the Social Informatics Course, work to acquire data directly related to our lives and societies, and to reformulate and store it in the most accessible and useful way to enable the development of our sustainable future.

Nobuhito Ohte

Professor, Social Informatics Course

He is a Professor of the Biosphere Informatics Laboratory in the Division of Biosphere Informatics at Kyoto University. His research themes are to understand mechanisms of hydrological controls of nutrient transformations and transportations in the forested catchment, and to elucidate the geographical variations of those ecosystem dynamics among various types of climatic and geological conditions. He holds a BA in forestry from Graduate School of Agriculture at Kyoto University in 1987, and a PhD also from Kyoto University in forest hydrology in 1992. He was awarded Biwako Prize for Ecology in 2013. He is currently an associate editor of Biogeosciences (European Geoscience Union).

Applications of Information Technologies Expanding

Information technologies are causing our society to make great strides, with data science, artificial intelligence (AI), and information search becoming an integral part of our lifestyles. Meanwhile, robots, autonomous vehicles, and other information systems with advanced AI continue to blend into our physical world. As one new information technology after another is being developed, how can information systems be created that achieve harmony with society and are accepted and utilized? The Course of Social Informatics is privileged to have a faculty comprised of experts in information technologies and teaching staff versed in applications of information technologies in such fields as biology, agriculture, medical science, disaster management, and education. If you wish to create information technologies that lead to practical applications or information systems that are of genuine use to society, this is the place you want to conduct your research!

Takayuki Kanda

Social Informatics Course

He received a bachelor's degree from the Department of Information Science, Kyoto University Faculty of Engineering, in 1998, and completed his doctoral program at the Department of Social Informatics, Kyoto University Graduate School of Informatics, in 2003 to earn a Ph.D. in Informatics. He joined ATR Intelligent Robotics and Communication Laboratories in 2003 to successively assume the positions of researcher, senior researcher, and Group Leader. Since 2018, he has held a professorship at the Department of Social Informatics, Kyoto University Graduate School of Informatics. His research interests include human-robot interactions, especially robots' autonomous dialogue mechanisms and social competencies, dialogues by anthropomorphic robots using their bodies, and their applications to everyday life settings.

Outline

Group and Teaching Staff

Group	Teaching Staff
Distributed Information Systems	
Human-Robot Interaction	Takayuki Kanda/Professor Dražen Brščić/Associate Professo Jani Even/Program-Specific Senior Lecturer Stela H. Seo/Assistant Professor Malcolm Doering/Program-Specific Assistant Professor Kanae Kochigami/Program-Specific Assistant Professor
Social Media	Keishi Tajima/Professor (Secondary appointment: Institute of Liberal Arts and Sciences)
Sociotechnical Design (Adjunct Unit)	Naomi Yamashita/Kyoto University Visiting Professor (NTT Communication Science Laboratories)
Consensus Informatics	Takayuki Ito/Professor Rafik Hadfi/Program-Specific Associate Professor Ryuta Arisaka/Assistant Professor Shiyao Ding/Assistant Professor Sofia Sahab/Program-Specific Assistant Professor Jawad Haqbeen/Program-Specific Assistant Professor
Information Security (Adjunct Unit)	Masayuki Abe/Kyoto University Visiting Professor Mehdi Tibouchi/Kyoto University Visiting Associate Professor (NTT Informatics Laboratories)
Bioresource Informatics	Hideyuki Doi/Professor Hideaki Nishizawa/Assistant Professor Satsuki Tsuji/Assistant Professor
Environmental Informatics	Nobuhito Ohte/Professor Lina A. Koyama/Associate Professor Masumi Hisano/Assistant Professor
Integrated Disaster Management Systems	Hirokazu Tatano/Professor Toshio Fujimi/Associate Professor Subhajyoti Samaddar/Program-Specific Associate Professor Huan Liu/Program-Specific Assistant Professor
Emergency Management for Disaster Reduction Systems	Katsuya Yamori /Professor Genta Nakano/Assistant Professor
Crisis Information Management System	Michinori Hatayama/Professor Kei Hiroi /Senior Lecturer
Medical Informatics	Tomohiro Kuroda/Professor Goshiro Yamamoto/Associate Professor Yukiko Mori /Senior Lecturer Chang Liu/Assistant Professor
Learning and Educational Technologies	Hiroaki Ogata/Professor Rwitajit Majumdar/Program-Specific Senior Lecturer Izumi Horikoshi/Assistant Professor
Data Engineering and Platform Research	Kazuyuki Shudo/Professor Shiori Hironaka/Assistant Professor

Curriculum of Social Informatics Course

Doctoral Program (Informatics)

3rd / 2nd / 1nd

Doctoral Thesis

Subjects provided by the Course (total 6 credits including 4 credits from seminars)

Seminar on Social Informatics, Adv. *E* (Mandatory, 2 credits)
Seminar on Social Information Model, Advanced A, B *E*
Seminar on Social Information Network, Advanced A, B *E*
Seminar on Biosphere Informatics, Advanced A, B *E*
Seminar on Regional Disaster Prevention Information Systems, Advanced A, B *E*
Seminar on Medical Informatics, Advanced A, B *E*
Seminar on Social informatics Analytics Infrastructure, Advanced A, B *E* (2 credits each)

Research Guidance

Master's Program (Informatics)

2nd / 1st

Master's Thesis

Subjects provided by the Course (optional 10 credits or more, including 6 credits from basic courses)

Advanced Subjects (2 credits each)
Multiagent SystemsHuman-Robot Interaction *E*, Biosphere Informatics *E*, Disaster Information
Emergency Management, Medical Informatics Informatics of E-business Information Education
Distributed Systems *E*, Cryptography and Information Society User Experience (UX) *E*, Service Modeling
Field based Learning/Problem based Learning (FBL/PBL) 1, 2

Basic Subjects (Assigned to M1, 2 credits each)
Information and Society *E*, Information System Analysis *E*, Practice of Information Systems *E*

General Subjects provided by the School

Interdisciplinary Subjects of the Perspectives in Informatics (Mandatory 2 credits)
Perspectives in Informatics 1 Perspectives in Informatics 2
Perspectives in Informatics 3*E* Perspectives in Informatics 4*E*
Perspectives in Informatics 5*E* (2 credits each)

Perspectives in Platform Studies (2 credits), Computational Science, Introduction (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credits), Information Analysis and Management, Exercise (1 credit), Social Contributions through Informatics *E* (1 credit)
Internship in the Field of Informatics *E* (1 credit)

Seminars and exercises for Master's Thesis (Mandatory 10 credits)

Advanced Study in Social Informatics 2 *E* (Assigned to M2, 5 credits)

Advanced Study in Social Informatics 1 *E* (Assigned to M1, 5 credits)

Specific courses provided by the school

Prior to admission — Fundamental background of the subjects in the Course, etc.

Preferred to understand the subjects on the right: Data structure and Algorithms → Fundamental Programing → Fundamental concepts of Computational

Note: Courses marked with the letter "E" will be provided in English.

Human-Robot Interaction

Intelligent robotics for our daily social environments

There are a growing number of everyday applications for artificial intelligence and robotics such as social robots, self-driving cars, and automated shops. We expect that future society will be ubiquitous with various robots. Towards such a robotized society, we aim to study robots that interact with people and operate in harmony alongside them. Such robots are embodied agents with sensory feedback that have the ability to interact in real-time with their environments. Consequently, we conduct fundamental research in intelligent robotics, human interaction, sensor networks, and artificial intelligence (AI). We are aiming for applications in the service industry, elderly care, health care, collaborative work places, and learning.

[Takayuki Kanda , Dražen Brščić , Jani Even , Stela H. Seo , Malcolm Doering , Kanae Kochigami]

Social Media

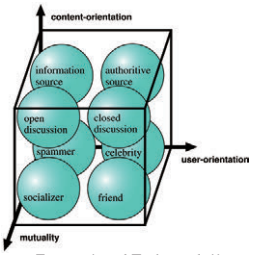
Information environment for sharing and utilizing all useful information in the world

"Sharing and utilizing all useful information in the world" may sound to you like a mission statement of a major search engine company. It has, however, been the dream of researchers in the area of database systems and information retrieval since a long time ago. Thanks to the advance of computer and network technologies, we can now easily share and utilize data of large volume and high diversity which we cannot even think about until decades ago, and this "dream" is not a daydream anymore but is the goal. To achieve this goal, we conduct research on technologies for collecting, analyzing, extracting information and technologies for retrieving information you want from the extracted information. Our recent research themes includes: extraction of social information from the Web, social network analysis, information retrieval, and information access interface.

[Keishi Tajima]

Web = distorted mirror
Need to remove distortion

Extraction of social information from the Web



Example of Twitter follow link classification

Outline

Sociotechnical Design (Adjunct Unit)

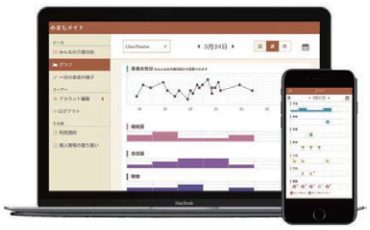
Toward an inclusive future society (in collaboration with NTT Corporation)

The progress of the information society has enabled people to connect with anyone more easily, but at the same has given rise to problems such as weakening of interpersonal relations, fragmentation, and isolation. These problems cannot be resolved simply by providing more opportunities to connect with other people or support for those who are isolated. It is crucial to engage the surrounding community and environment in order to achieve solutions. This laboratory pursues research on basic communication technologies that foster deeper human relations and ensure that diverse individuals are included rather than left isolated.

The research topics addressed include:

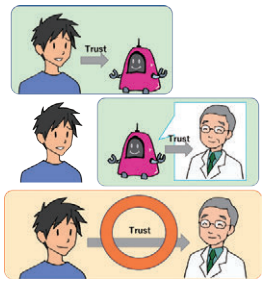
- Information technologies for the realization of inclusive societies
- Basic communication technologies that foster deeper human relations
- Information technologies that serve the collective good
- Collaborative technologies that enable sustainable work styles

[NTT Communication Science Laboratories: Naomi Yamashita]



"Minamo-mate": a support tool for families of people with depression

Support for non-native speakers in multilingual projects



Dialogue agents fostering person-to-person trust

Consensus Informatics

Toward AI-powered Collective Intelligence

Our interest lies in AI-powered collective intelligence, whereby people and computers or AI agents interact to form consensus and cooperate with each other. Recent research has shown that human collective intelligence is superior to individual intelligence. Adding highly networked computers and AI to a human population therefore has the potential to achieve higher levels of intelligence on a large scale and with great efficiency. Spectacular advances in AI technology in recent years, typified by large-scale language models, have enabled AI agents with dramatically improved accuracy. So, by getting these AI agents and humans to build consensus and cooperate with each other, we hope to demonstrate an unprecedented degree of collective intelligence, with the ultimate goal of shaping totally new social systems.

The multi-agent AI presents a methodology and concepts that allow us to realize such new social systems and promote them with collective intellect and intelligent information technology. In multi-agent systems, we mainly explore possibilities of new social systems and implement such

systems, while seeking the essence of social intelligence, with a focus on interdisciplinary studies with such fields as distributed AI, simulations, robotics, and game theory.

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We will pursue both high ideals (theoretical studies) and down-to-earth approaches (commercialization of research achievements).

[Takayuki Ito , Rafik Hadfi , Ryuta Arisaka , Shiyao Ding , Sofia Sahab , Jawad Haqbeen]

Column *From the World to Japan, from Japan to the World*

Over 40 foreign students are enrolled in the Course of Social Informatics, representing more than 15 countries. You may obtain a sense of global community by studying in such a diverse environment. Many students from the Course of Social Informatics make presentations, discuss research, and join internship programs abroad. A welcome party is held in October to welcome newcomers from foreign countries, and various kinds of international exchanges happen on a daily basis.

An international event

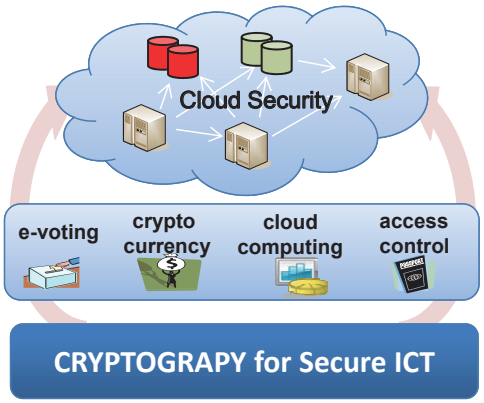
Research presentation at an international conference (Canada)

Information Security (Adjunct Unit)

Creating a safe digital society through cryptography(in collaboration with NTT Corporation)

In today's world, where the Internet is increasingly used to conduct electronic transactions such as electronic settlements and bidding in online auctions, or to carry out functions required by the government, such as the filing of tax returns, the maintenance of secure network services is becoming increasingly important. Modern cryptography is a key technology to achieve such security, and goes far beyond concealment technology to prevent eavesdropping. It is a field of intense study that is developing rapidly. It involves technical and logical systems which include digital signatures that verify the identity of the party you are communicating with and guarantee the authenticity of the data (which means that the data have not been altered), as well as cryptographic protocols that enable advanced network services which guarantee privacy. In our laboratory, we will study and develop various applied cryptographic techniques commonly used today such as public key cryptosystems, crypto currency, electronic voting, and other applications suitable for cloud computing with rigorous security analysis based on a firm theoretical foundation.

[NTT Social Informatics Laboratories: Masayuki Abe, Mehdi Tibouchi]



Outline

Bioresource Informatics

Seeking utilization and conservation of bioresources

Our research and education efforts are directed at a wide range of subjects to do with the extraction, analysis, and utilization of information, in connection to the use and conservation of terrestrial and marine biological resources. We are particularly focused on developing biologging, biotelemetry, and environmental DNA methods for collecting bioresource information, and tackling various basic and applied hypotheses related to bioresources, biology, and ecology using big data in the form of geographic information, satellite information, and large databases.

[Hideyuki Doi , Hideaki Nishizawa , Satsuki Tsuji]



Various methods and techniques are applied

Environmental Informatics

Seeking conservation and utilization of ecosystems

Recently, society has been interested in environmental changes at various spatial/temporal scales. This group works on topics such as understanding/monitoring environmental information or the role of various organisms in ecosystems. Our research interests cover various fields related to terrestrial ecosystems, ranging from their diverse inhabitants such as plants, animals and microbes to their complete physical environment. We study how these relate to other organisms or environments in the ecosystems, or how human society influences them with respect to their sustainability in a changing environment. Various methods/approaches such as field investigation, questionnaires, remote-sensing or chemical/isotopic analyses are applied to collect and analyze key information about these ecosystems and organisms.

[Nobuhito Ohte , Lina A. Koyama , Masumi Hisano]



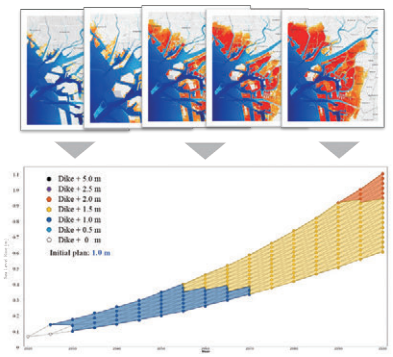
Fieldwork is conducted in various types of sites

Integrated Disaster Management Systems

Aiming to build disaster prevention systems to ensure a safe and secure society

To build a safe and secure society, we need to put in place disaster prevention systems that will enable the planning and implementation of disaster risk control, financing, and other integrated policies in a rational manner. We will take an informational, organizational and economic approach to find out what kind of disaster prevention system will result in cities with greater resistance to natural disasters.

[Hirokazu Tatano , Toshio Fujimi , Subhajyoti Samaddar , Huan Liu]



Flood Risk Communication Support System

Emergency Management for Disaster Reduction Systems

Social Scientific research for disaster damage reduction

Society is required to prepare and take actions to reduce the potential damage of disasters by sharing information and knowledge concerning potential disaster risks through communication among the members of society. This laboratory aims at developing disaster risk reduction systems through practical studies from the perspective of social psychology and systems analysis. The research interests include disaster psychology, disaster risk information and communication, disaster education, regional crisis management and decision making support, financing for disaster recovery.

[Katsuya Yamori , Genta Nakano]

Disaster education materials developed in our lab

Crisis Information Management System

Disaster Information Systems with Information Technology

Our goal is to establish design methodologies for the department of effective disaster management systems against various types of disaster for National/Local Governments, local communities in affected areas and disaster relief organizations. One of the most important key technologies are spatial temporal database to record, visualize and analyze current/near future status in affected areas. In addition our laboratory focuses on human behavior before/during/after disasters as targets to supply valuable services.

[Michinori Hatayama , Kei Hiroi]

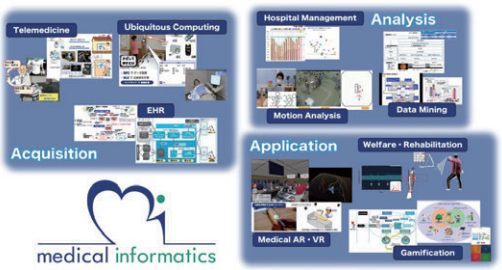
Development of building damage certification system considering operator's ability in the Great East Japan Earthquake

Outline

Medical Informatics

Exploring approaches to medicine in the information age

The Medical Informatics Laboratory seeks to create a new vision for medicine in the information age by developing information platforms, analyzing real-life clinical information, and providing feasible information support for existing clinical entities. Our research covers all areas at the interface of information and medicine, including system development for ubiquitous hospital information systems, remote medical information systems, electronic health records, and other systems, hospital administration analysis, clinical epidemiological information analysis, data health research, VR-based medical education, clinical decision and surgery support, and information support for health tourism.



[Tomohiro Kuroda , Goshiro Yamamoto , Yukiko Mori , Chang Liu]

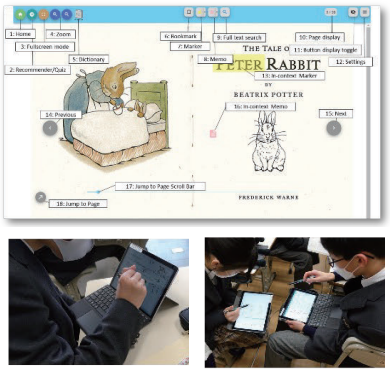
Learning and Educational Technologies

Information Systems that Support Learning and Education

Our research focuses on information technology that supports activities in education and learning by analyzing their log data:

(1) Development of the infrastructure for accumulation and analysis of educational big data
(2) Analysis of learning experiences by using life log technologies
(3) Knowledge awareness for collaborative learning support
(4) Educational systems for Information security and ethics

[Hiroaki Ogata , Rwitajit Majumdar , Izumi Horikoshi]



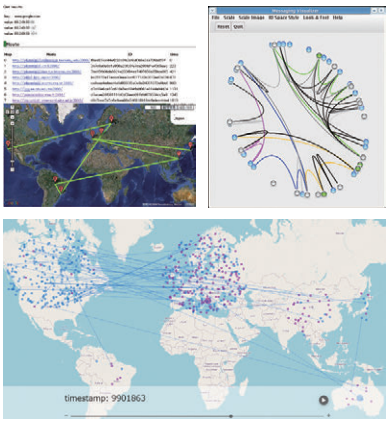
Example of a learning analytics system (LEAF/BookRoll/LogPallet)

Data Engineering and Platform Research

Research in support of internet-scale data infrastructure

Centering on the configuration of distributed systems ranging from several computers to tens of thousands of computers in size, this labor atory's research addresses topics from core systems for the handling of big data to methods for analysis of such data. Specific topics include:

- **Peer-to-peer (decentralized-distributed system) algorithms**
- **Large-scale distributed system simulations**
- **Blockchain networks**
- **Decentralized-distributed machine learning methods**
- **Social graph analysis methods**



[Kazuyuki Shudo , Shiori Hironaka]

Special Education Program of Social Informatics Course

1. Specialized Subjects and special Lecture

Special lecture

In the first year of the Master's program, students are introduced to specialized subjects including the design and analysis of information systems, and the relationship between information and society. They can acquire the fundamentals of informatics from the ground up through these subjects, and even students with less specific experience in informatics can benefit by combining their informatics and other expertise. In addition, we have more than 30 special lectures a year in our course, for which we invite lecturers from various universities, research institutes and government offices.

2. Education for Innovation

FBL (Field based Learning)/
PBL (Problem based Learning)

The Course of Social Informatics joins Kyoto University Design School, in which students take a course titled "FBL (Field based Learning)/ PBL (Problembased Learning)" that helps them acquire the skills needed to find and solve real-world problems. In this course, students select one of a variety of themes, and form small groups to tackle specific problems. The themes include "Designing a new environment for education: creating a place that fosters creativity", "Design of places for conversation over books and tea", and "Organization design in crowd-sourcing" Kyoto University Summer Design School arose from activities mainly led by the ourse of Social Informatics, and has become a seasonal tradition in summer, attracting more than 250 participants to share the same innovative space. Over 20 different kinds of themes were proposed by companies and universities, and were tackled by many students eager to solve real-world problems: they went into the field, and used trial-and-error methods by actually creating prototypes. The Course of Social Informatics proposed themes such as "Predicting Kyoto in 2050 by simulation" and "Designing safety into apartment buildings: first priority, disaster prevention".

3. Education for Globalization

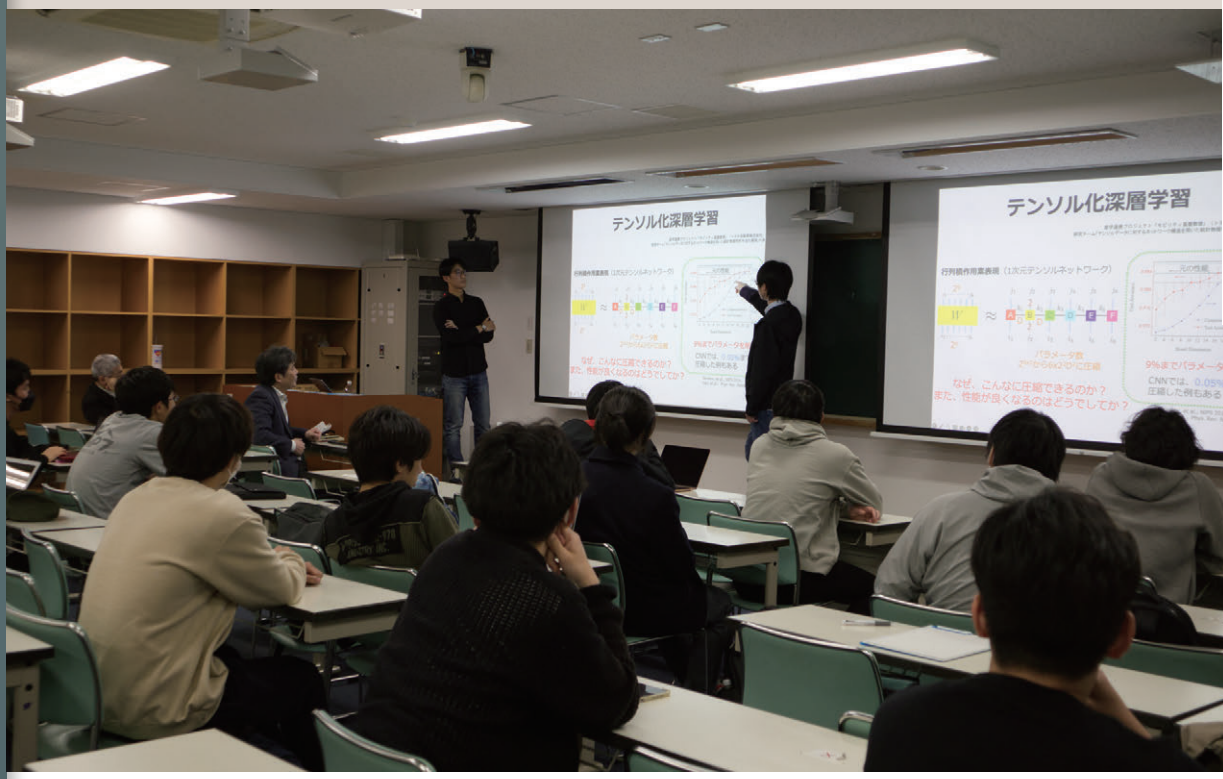
Strategic communication seminar

Course of Social Informatics has an International Course Program in the curriculum. Students in the International Course Programs can take lectures in English, receive guidance in English from their supervisors, and acquire Master's and Doctoral degrees exclusively in English. Students who complete the course will receive a certificate of completion for the international course.

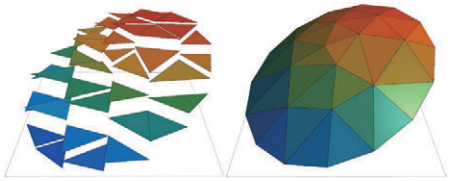
Mathematical Modeling and Analysis of Phenomena

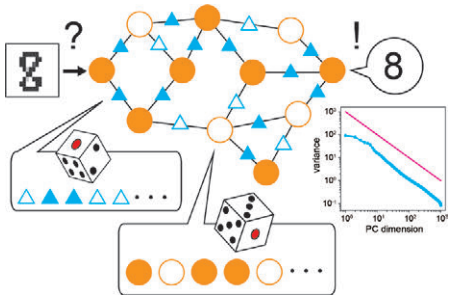
— In Pursuit of Introduction of Science and Engineering —

The essence of science is to derive principles from observations, thereby revealing the simple structures that underlie what appear to be complex phenomena.
Mathematical sciences, in particular, use mathematical approaches to investigate "mathematical models", which are derived through experimentation.
The modern frontier of mathematical sciences considers various new mathematical models, including those for biological and social phenomena, in addition to more traditional models in natural sciences. These models are investigated through analytical approaches as well as numerical simulations in order to understand the phenomena.
The knowledge thus obtained is employed to develop innovative technologies or to predict future developments, and new methodologies are devised for deeper understanding of phenomena.
In its research and educational activities, our course pays particular attention to large-scale and/or highly non-linear complex phenomena.
Particularly in education, we aim at providing students with both scientific perspectives, which help them to understand principles, and engineering perspectives which are useful in solving real problems in manufacturing.
This two-pronged approach gives students comprehensive overviews on both science and engineering in mathematical sciences.



Advanced Mathematical Sciences





An Invitation to Mathematical Sciences

In Graduate School of Informatics, we regard "mathematical modeling and analysis of natural, social and biological phenomena" as an important foundation of what we aim at; i.e., "informatics" in the broad sense of the term, which includes not only traditional computer science but also related disciplines such as mathematical sciences, applied physics, etc.

Indeed, we have placed importance on research and education in mathematical sciences since the establishment of our school in 1998 because they are considered to form the academic basis of our disciplines. At the time of inauguration of the school, we considered it appropriate to name ourselves the "Department of Applied Analysis and Complex Dynamical Systems", since "complex dynamical systems" was the phrase that symbolized the advanced mathematical sciences of the time. However, the relentless advancement of mathematical sciences gradually made "complex dynamical systems" not necessarily the best phrase to express what we are. Meanwhile, development of computers and networks has made it possible to deal more easily with so-called “big data,” thus making computers and networks increasingly important in social life as well as in research and education in mathematical modeling and analysis of natural, social and biological phenomena. With these developments in mind, we have decided to change the name of our department to "Department of Advanced Mathematical Sciences," as of April 2017. We believe that the new name reaffirms and clarifies our directions for both education and research.

In the broad research area of "advanced mathematical sciences," we are particularly interested in "mathematical modeling and computer simulations of phenomena," which constitute the basis of our activities. Computer simulations and data analyses are now vitally important in several branches of science and engineering. New applications of computational methods are found in biology, social sciences, etc. and, of course, as more conventional applications in mechanics. These new trends in mathematical modeling of phenomena call for new methodologies, including probabilistic and fractal approaches in addition to classical differential equations and discrete models. New developments in computer simulation include large-scale, high-performance computing, use of new computational environments such as multiple-precision arithmetics, etc. Our course conducts research and education in such new and advanced areas of mathematical sciences.

Traditionally in Japan, fundamental education in mathematical sciences has been carried out in schools of science and more application-oriented education has been provided by engineering schools. However, despite its small size, our course has some faculty members with science backgrounds and others with engineering backgrounds. Our aim is to "integrate science and engineering" and develop students with comprehensive perspectives of advanced mathematical sciences. We also emphasize individualized teaching as well as independent learning by each student, in line with Kyoto University’s principle of "self-learning based on dialogue."

Toshio Aoyagi

Professor, Advanced Mathematical Sciences Course

Toshio Aoyagi, Sc.D., earned his doctoral degree from Kyoto University Graduate School of Science in 1993. Since graduating, he has held such positions as Research Associate, Department of Applied Mathematics and Physics, Kyoto University Faculty of Engineering and Lecturer and then Associate Professor, Department of Applied Analysis and Complex Dynamical Systems, Kyoto University Graduate School of Informatics, before assuming his present position in 2014. His research specialties are non-linear physics and theoretical neuroscience, with a focus on the analysis of rhythmic phenomena and research into coupled dynamical systems on networks. He is a member of the Physical Society of Japan, Japan Neuroscience Society, Japanese Society for Mathematical Biology, and Japanese Neural Network Society. 2023 Chairperson of Course.

Outline

Laboratory and Teaching Staff

Laboratory	Teaching Staff
Applied Analysis	Yuusuke Iso/Professor　Jun Kigami/Professor　Hiroshi Fujiwara/Associate Professor Daisuke Shiraishi/Associate Professor　Masayoshi Kubo/Senior Lecturer Li Douglas/Program-Specific Senior Lecturer　Daisuke Kawagoe/Assistant Professor
Nonlinear Physics **(Nonlinear Dynamics and Computational Statistical Physics)**	Syuji Miyazaki/Senior Lecturer　Kenji Harada/Assistant Professor
Nonlinear Physics **(Non-equilibrium Physics and Theoretical Neuroscience)**	Toshio Aoyagi/Professor　Jun-nosuke Teramae/Associate Professor Hiroki Tutu/Assistant Professor
Computational Mechanics	Hitoshi Yoshikawa/Associate Professor　Kazuki Niino/Assistant Professor
Industrial Mathematics	Satoshi Taguchi/Professor　Tetsuro Tsuji/Associate Professor
Statistical Signal Processing	Kazunori Hayashi/Professor (Secondary appointment : Institute of Liberal Arts and Sciences)

Curriculum of Advanced Mathematical Sciences Course

Doctoral Program (Informatics)

3rd / 2nd / 1st: Doctoral Thesis

Subjects provided by the Course (total 6 credits)
Seminar on Mathematical Sciences (Advanced) *E* (2credits Mandatory)
Seminar on Applied Analysis (Advanced A & B) *E* (2 credits each), Seminar on Nonlinear Physics (Advanced A & B) *E* (2 credits each), Seminar on Applied Mathematical Sciences (Advanced A & B)*E* (2 credits each)

Research Guidance

Master's Program (Informatics)

Master's Thesis

2nd / 1st:

Subjects provided by the Course (Optional 8 credits or more)

Advanced Subjects (A and B are offered every other year)
Topics in Differential Equations A,B (2 credits each), Topics in Nonlinear Analysis A,B (2 credits each) ,Topics in Applied Analysis Ⅰ, Ⅱ (1 credit each), Topics in Nonlinear Dynamics A,B (2 credits each) ,Topics in Nonequilibrium Physics A,B (2 credits each) Topics in Nonlinear Physics Ⅰ, Ⅱ (1 credit each), Topics in Computational Mechanics A,B (2 credits each) Topics in Mathematical Sciences A,B (2 credits each), Topics in Applied Mathematical Sciences Ⅰ, Ⅱ (1 credit each)

Basic Subjects (A and B are offered every other year)
Applied Analysis A,B (2 credits each), Nonlinear Physics A,B (2 credits each), Applied Mathematical Sciences A,B (2 credits each)

Seminar Subjects
Seminar on Applied Analysis Ⅱ
Seminar in Nonlinear Physics Ⅱ
Seminar in Applied Mathematical Sciences Ⅱ (Those planning to proceed to doctoral program: Assigned to M2, 4 credits each)
Seminar on Applied Analysis Ⅰ
Seminar in Nonlinear Physics Ⅰ
Seminar in Applied Mathematical Sciences Ⅰ
(Assigned to M1, 4 credits each)

Seminars and exercises for Master's thesis (Mandatory 8 credits)

Advanced Study in Mathematical Sciences 2 (Assigned to M2, 6 credits)

Advanced Study in Mathematical Sciences 1 (Assigned to M1, 2 credits)

General Subjects provided by the School
(Compulsory elective
2 or more credits and 4 credits or less for ◎ subjects)

Interdisciplinary Subjects of the Perspectives in Informatics
◎Perspectives in Informatics 1 ◎Perspectives in Informatics 2
◎Perspectives in Informatics 3 ◎Perspectives in Informatics 4
◎Perspectives in Informatics 5 (2 credits each)

◎Perspectives in Platform Studies (2 credits), Computational Science, Introduction(2 credits), Computational Science, Exercise A (1 credits), ◎Information and Intellectual Property(2 credits), Innovation and Information(2 credits), Information Analysis and Management(2 credits), Information Analysis and Management, Exercise (1 credits), Social Contributions through Informatics(1 credits), Internship in the Field of Informatics (1 credits),

Specific subjects provided by the school

Prior to admission	Calculus	Linear Algebra	Fundamentals of Ordinary Differential Equations	Fundamentals of Complex Analysis	Mechanics of Particles, Systems of Particles, and Rigid Bodies	Academic Foundations at Undergraduate Level for Study at the Course

Note: Subjects marked with the letter "*E*" will be provided in English.

Admission, Curriculum and Other Efforts in Our Course

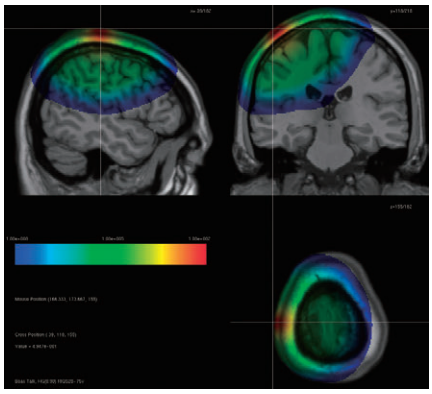
In study and research of advanced mathematical sciences, one needs both basic mathematical skills as well as knowledge of his/her specialist field. Accordingly, in the entrance exam, all applicants for our Master's course are required to solve basic problems in linear algebra and calculus together with one problem of their choice related to their respective specialties. Final decisions on acceptance are made through interviews with those applicants who score above a certain level in the written exam, since it is not desirable to make such decisions based only on the results of the written exam where one point may be the difference between a pass mark and failure. The interviews will be conducted by all the faculty members in order to determine if applicant's interests match the expertise of our faculties. In the entrance exam for the Ph.D. course, final decisions on acceptance are made based on the achievements of each candidate in his/her research work, which are evaluated in interviews conducted by all the faculty members.

Our curriculum for the Master course consists of both general and specialized subjects. All students are advised to take three general subjects, which help them to develop both scientific and engineering perspectives in mathematical sciences. Research advice is given mainly on a one-to-one basis, taking into account each student's aptitude. For those wishing to go on to Ph.D. courses, we provide Seminar II (for second-year students), which is designed to give students opportunities to learn advanced topics in addition to receiving standard research mentoring. In the Ph.D. course, students can receive mentoring not only from their advisers but also from other professors in our course and affiliated professors from science and engineering schools. This system gives students access to a broader spectrum of state-of-the-art knowledge in the mathematical sciences. Students thus have opportunities to deepen their expertise and to obtain a broad appreciation of mathematical sciences from both scientific and engineering perspectives, which we believe to be a unique feature of the education provided by our course.

In addition, almost every year, we offer open, public seminars on topical subjects.

Applied Analysis Laboratory

Analysis in the 21st Century



Numerical Simulation of Light Propagation in a Human Brain

Numerical Analysis of (Partial) Differential Equations, Numerical and Mathematical Analyses

I am interested in both mathematical and numerical analyses in research regarding the determination of unknown coefficients and other inverse problems, as well as boundary value problems and other forward problems with respect to partial differential equations that describe mechanical and physical phenomena. [Yuusuke Iso]

Fractal Analysis, Fractal Geometry

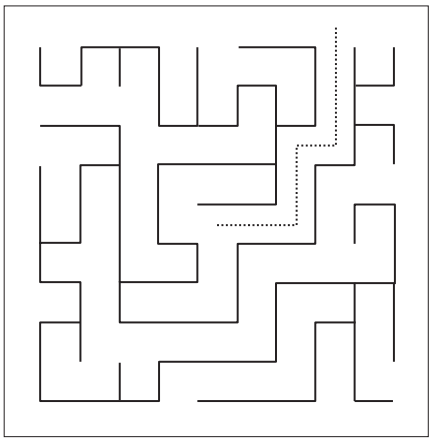
I am interested in the mathematical theory of problems concerning heat and wave propagation in fractal concept models –new models for the natural world. [Jun Kigami]

Numerical Analysis of Ill-posed Problems, Design and Implementation of Multi-precision Arithmetic Environments

I am interested in research concerning regularization methods and numerical analysis of multiple-precision calculations with the aim of solving inverse problems that occur in mechanics and geophysics. [Hiroshi Fujiwara]

Structure of Brownian Motion and Random Walk

How does the trace of Brownian motion look like? What can we say about the structure of random walk trace? Such questions have fascinated probabilists and mathematical physicists for a long time, and they continue to be an unending source of challenging problems. I am interested in the nature of sample paths of these fundamental processes. [Daisuke Shiraishi]



Uniform spanning tree (solid line) and dual path (dotted line)

Inverse Problem Analysis, Numerical Analysis of (Partial) Differential Equations, Partial Differential Equations, Brain Model Mathematical Research

I mathematically analyze partial differential equations that appear in mathematical physics and mathematically and numerically analyze the inverse problems found in these partial differential equations, where the unknown coefficients of these inverse problems are determined by observed data. [Masayoshi Kubo]

Numerical Analysis of Differential Equations and Data-Driven Science

I am interested in numerical simulations of differential equations and data driven modelling in natural science, technology and social sciences. [Li Douglas]

Integro-Differential Equations, Spectral Analysis

I study regularity of solutions to integro-differential equations appearing in kinetic theory and optics. Also, I work in spectral analysis on boundary integral operators which are related to the theory of elasticity. [Daisuke Kawagoe]

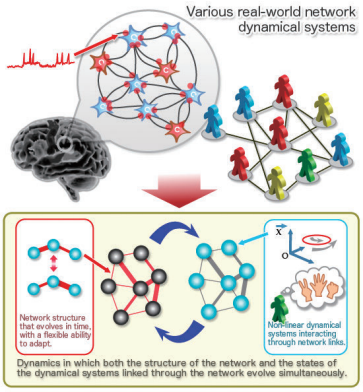
Outline

Nonlinear Physics Laboratory

Group of Non-equilibrium Physics and Theoretical Neuroscience

From nonlinear physics to theory of networks, as well as living and neural systems

I am particularly interested in systems composed of many simple elements that, through cooperative interactions, come to exhibit complex behavior and high-level functions, such as not only many physical systems, but also biological and social systems. Co-evolution involving the intricate interplay between the dynamics of the network and the elements is a key concept for understanding the self-organized, flexible nature of real-world network systems. I study such cooperative phenomena in systems of this kind, focusing on rhythmic phenomena and chaos from the perspective of nonlinear dynamics. [Toshio Aoyagi]

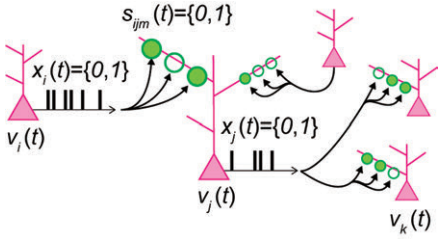


Neural systems and social networks are nonlinear dynamic systems that have a high degree of freedom and develop as their dynamic elements change the structure of their interconnections.

Nonlinear physics of computation and learning in the brain

The brain is a highly complex network composed of about 100 billion of neurons. Spike propagation along the network and plasticity of synaptic connection of them cause high-dimensional nonlinear dynamics, which is the nature of neural computation and learning. Central questions, however, still remain elusive.

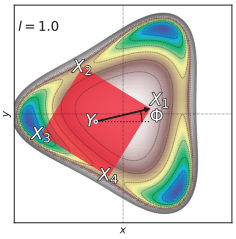
What is intelligence? What is underlying principles of neural computation and learning? Our recent study, for example, reveals significant roles of spontaneous fluctuation in neural computation. By integrating neuroscience, computer science, and nonlinear physics, here we are trying to answer these questions and trying to develop fully brain-inspire AIs. [Jun-nosuke Teramae]



Conceptual diagram of neurons (pink) in the brain interacting through synapses (green circles) that transmit impulse currents in a process called "spike firing." The process can be mathematically analyzed by modeling the states of neurons and synapses as random variables.

Mathematical models for molecular machines

Biological molecular motors are amazing machines that generate useful movement (as a pump or a porter). The relationship between the structures of proteins and their highly efficient energy conversion, even under a fluctuating environment, remains mysterious. I explore the underlying principles of such molecular machines with mathematical models. [Hiroki Tutu]

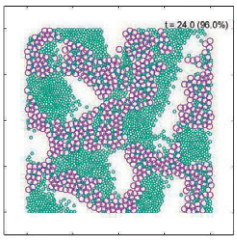


Rotary ratchet model consisting of a rotor (rigid body consisting of four points) and a rotor housing (potential) that simulates a Wankel rotary engine

Group of Nonlinear Dynamics and Computational Statistical Physics

Study on powders and charged particles under cyclic external forces

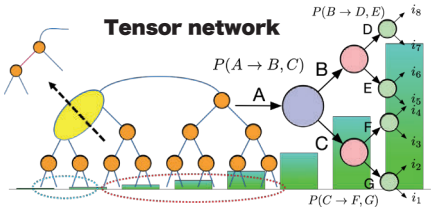
Inspired by experiments in which several micron-size charged corpuscles are injected into an AC trap, a simplified version of a Paul ion trap, and prior studies into the particle model of ion channels and its anomalous transport, we mainly study collective motions of granular materials and charged corpuscles, which are subject to periodic external force. We also propose mathematical models for numerical analysis that faithfully reproduce experiment settings and analyze critical phenomena incidental to collective motions of macroscopic charged corpuscles injected into an AC trap and various types of bifurcations that occur in vibrating powder. [Syuji Miyazaki]



It is known that when two different powders, one of large and one of small grain size, are horizontally vibrated, the two powders separate, causing a stripe pattern to form.
We discovered that when powders, one of large and one of small grain size, each one with a size distribution centered around its average grain size, are vibrated horizontally, the two powders separate, causing a mesh pattern to form.

Statistical physics using computational approaches

Using the computational approach, we advance statistical physical research for the emerging properties in complex systems consisting of many elements with nonlinear interactions. My research areas range from the atomic scale to the real world, e.g.,quantum critical phenomena and infectious diseases. Based on tensor network formalism, I am also working on informational processing technology, such as classical and quantum machine learning. [Kenji Harada]

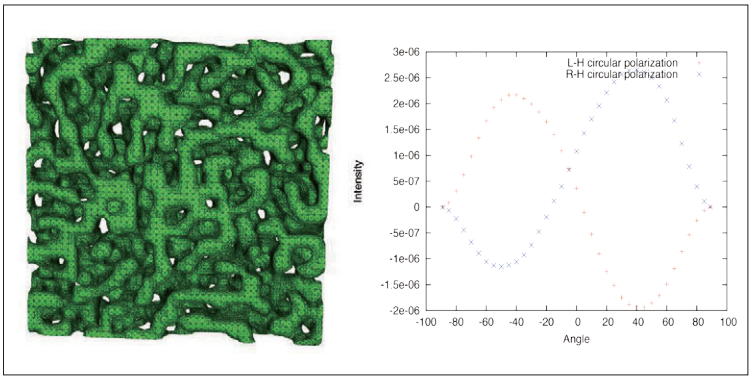


Researchers actively study new compression methods for large data sets and deep learning models with exponentially growing parameters using tensor network representation.

Computational Mechanics Laboratory

Computer simulations:development of fast BIEMs and their applications to engineering problems

Numerical simulations provide powerful tools for solving various problems in science and engineering. Computational mechanics, together with theoretical and experimental mechanics, is an effective method of investigating mechanical phenomena in engineering based on numerical simulations. Our group specializes in Boundary Integral Equation Methods (BIEM) which are among major techniques in computational mechanics. BIEMs are particularly effective in wave and fracture problems. We focus on fast BIEMs and their applications to large-scale problems with special interest in electromagnetic wave propagations in periodic structures, which have many applications in optics. Other topics of interest include shape optimization problems, eigenvalue problems and inverse problems. [Hitoshi Yoshikawa , Kazuki Niino]



A nanoporous gold mesh (left) and example of numerical computation of its transverse photo-induced voltage (right)

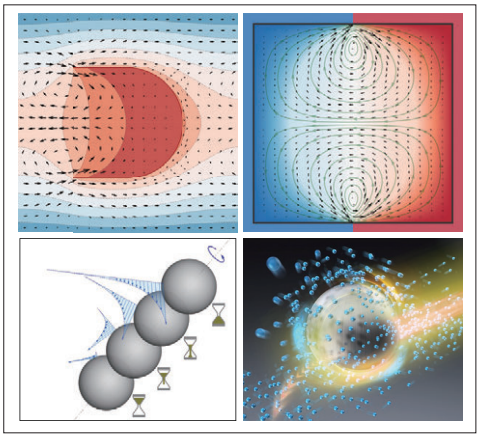
Industrial Mathematics Laboratory

Toward new fluid mechanics for non-equilibrium flows

In our group we investigate the behavior of non-equilibrium flows based on kinetic theory describing the collective behavior of innumerable particles.

We aim at understanding mechanical and/or thermodynamic properties of non-equilibrium flows both theoretically and numerically. We also aim at elaborating continuum theory and applying it to non-equilibrium flows, by deriving suitable mathematical models for non-equilibrium flows. [Satoshi Taguchi]

Recent advances in micro/nanoscale technologies require the understanding of transport phenomena in micro/nanoscale and their control. For this reason there is a growing interest in the research of non-equilibrium flows. In particular, we aim at investigating moving boundary problems for non-equilibrium flows and the motion of tiny materials (or particles) driven by non-equilibrium effects from the view point of mathematical sciences and from experimental view points. We also aim at integrating them in industrial applications. [Tetsuro Tsuji]

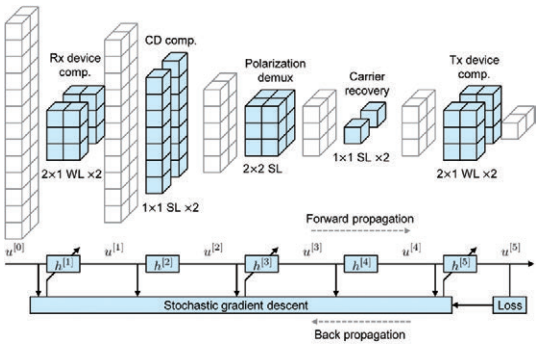


Unidirectional flow around a heated U-shaped body (top left)
Flow caused by a discontinuous wall temperature in a vessel (top right)
Flow caused by a rotating sphere impulsively set into motion (bottom left)
The Magnus effect of a spinning microparticle (bottom right)

Statistical Signal Processing Laboratory

Integration of Model-based and Data-driven Approaches

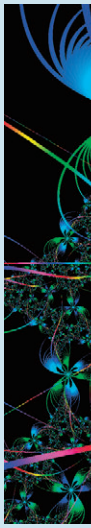
In the discipline of statistical signal processing, we try to systematize methodologies for extracting useful information from raw observation data. This has a wide range of applications in telecommunications, as well as measurement, image processing, and biological signal processing. Statistical signal processing is a valuable tool for tackling various kinds of problems relating to data science, including data sensing, collection, transmission, analysis, and utilization. We have recently been studying methods for solving underdetermined linear inverse problems that make use of the sparsity and discreteness of signals. [Kazunori Hayashi]

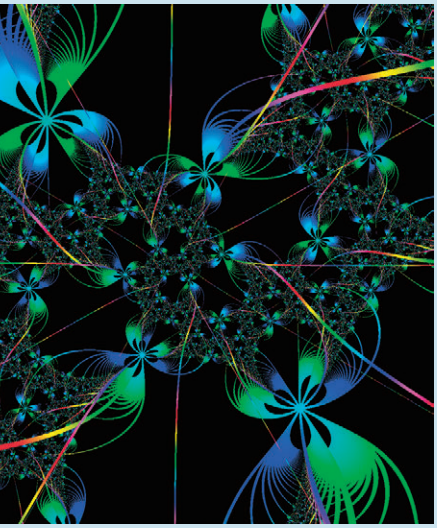


Example of optical communication receiver configuration using "deep unfolding"
Combining traditional telecommunications knowledge with a data-driven approach makes it possible to determine all parameters in an optical communication receiver system at once based on the loss function at output.

Using Applied Mathematics and Physics to Seek Solutions to Problems in Engineering/ Natural Systems

In the highly advanced information society of today, we encounter various situations that involve modeling and analysis of complex and large-scale systems, their control, design, and operation.
In these situations, it is extremely important to uncover common mathematical structures shared by those problems which are seemingly unrelated, and to develop mathematical methods to solve them, in addition to acquiring specialized knowledge of individual disciplines such as information technology, electricity, mechanics, and chemistry.
From this viewpoint, the seven laboratories of the Course of Applied Mathematics and Physics undertake leading-edge research on applied mathematical analysis, discrete mathematics, system optimization, control systems theory, applied mathematical modeling (adjunct unit), physical statistics, and dynamical system theory.





Universality of the Power law and Establishing Risk Indicators

The discovery and application of a super generalized central limit theorem

Why are power laws so prevalent in nature and the universe? That is the mathematical question that sparked this journey. Power laws, which are different to Gaussian distributions, can be asymmetric and remarkably diverse. The mathematical basis for such power laws can be traced back to a generalization of the central limit theorem, stating that the sum of random variables converges to a Gaussian distribution. While examining this mathematical basis, we constructed an algorithm to accurately estimate power laws from the massive amounts of data about the world that we now have access to. This has led us to develop new data analysis methodology for identifying real-time risk indicators for financial markets. As well as in financial markets, power laws also appear in many aspects, including physical phenomena in the universe. A power law is a common mathematical concept that sheds light in fields as wide-ranging as statistical physics, probability theory, chaos theory, cosmology, financial markets, neuroscience, and number theory (Riemann zeta function). Join us on this voyage of discovery! It has only just begun.

Ken Umeno

Professor, Applied Mathematics and Physics Course

Professor Umeno received his Doctoral Degree March 1995 from the University of Tokyo. In April 1995, he was a special postdoctoral researcher at the Institute of Physical and Chemical Research (RIKEN). From 1998 until he joined Kyoto University in 2012, he worked for Japan' s Ministry of Posts and Telecommunications (currently the National Institute of Information and Communications Technology). From 2005 to 2010, he was the Laboratory Head of the Next Generation Mobile Laboratory of RIKEN. He has been a Professor with Graduate School of Informatics, Kyoto University, since 2012. His research specialty is chaos theory, complex systems, and statistical mechanics. His recent invention is correlation analysis of GNSS data for detecting ionospheric Precursors before large earthquakes and is currently investigating in uncovering the physical mechanism to generate electro-magnetic anomalies. Together earthquake, he is also interested in physically inspired model of Financial Crisis as critical phenomena of phase transition in statistical mechanics.

Mathematics and Computers for Solving Problems through Optimization

As the concept of "optimization" has become increasingly familiar to people, technical terms such as "optimization" and "optimal solution" have made their way into everyday language. In the field of applied mathematics, we first describe "everyday optimization" as an "mathematical optimization model" that enables computers to deal with. Then we develop algorithms to find optimal solutions of such optimization models with large-scale and complex real-world applications.

Our laboratory deals mainly with continuous optimization, in which the candidate optimal solutions are expressed as continuous variables. Continuous optimization is an essential tool for deep learning and financial engineering. Why not come along and take advantage of the power of applied mathematics to help us shape a more optimal societyfor the benefit of many people?

Nobuo Yamashita

Professor, Applied Mathematics and Physics Course

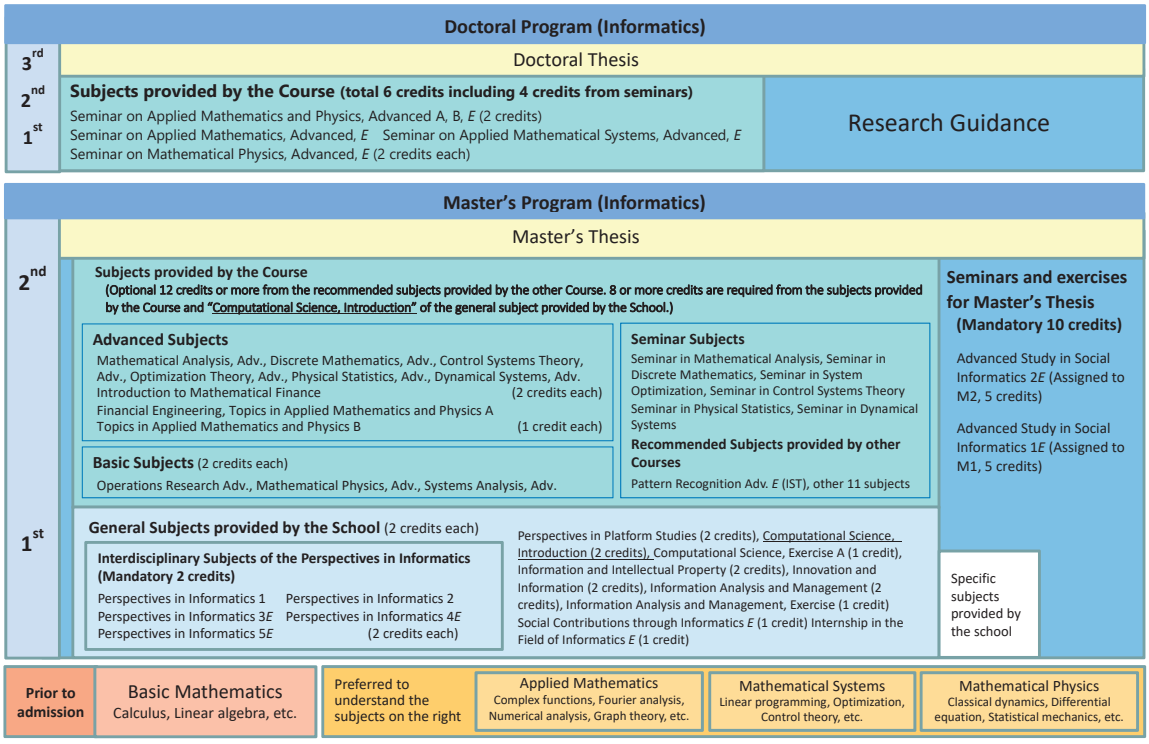
Professor Yamashita received his Doctorate degree in March 1996 from Nara Institute of Science and Technology. In April 1996 he was a research fellow at Japan Society for the Promotion of Science. In August 1997 he was appointed an assistant professor at the Section of Applied Mathematics and Physics, School of Engineering, Kyoto University. In April 2005 he became an associate professor at the department of Applied Mathematics and Physics, Graduate School of Informatics, and In July 2014 he was promoted to professor. His research specialty is continuous optimization, covering a broad range of fields which include, among others, large-scale optimization, equilibrium problems, and nonlinear equations.

Outline

Group and Teaching Staff

Group	Teaching Staff
Applied Mathematical Analysis	Satoshi Tsujimoto/Professor
Discrete Mathematics	Kazuya Haraguchi/Associate Professor
System Optimization	Nobuo Yamashita/Professor　Ellen Hidemi Fukuda/Associate Professor Hiroyuki Sato/Associate Professor　Yuya Yamakawa/Assistant Professor
Control Systems Theory	Kenji Kashima/Associate Professor　Kentaro Ohki/Assistant Professor
Physical Statistics	Ken Umeno/Professor　Erica Uehara/Senior Lecturer　Atsushi Iwasaki/Assistant Professor
Dynamical Systems	Kazuyuki Yagasaki/Professor　Mitsuru Shibayama/Associate Professor Yoshiyuki Yamaguchi/Assistant Professor
Applied Mathematical Modeling (Adjunct Unit)	Yoichi Nonaka/Adjunct Professor Yoshiyasu Takahashi/Adjunct Associate Professor (Hitachi Ltd.)

Curriculum of Applied Mathematics and Physics Course



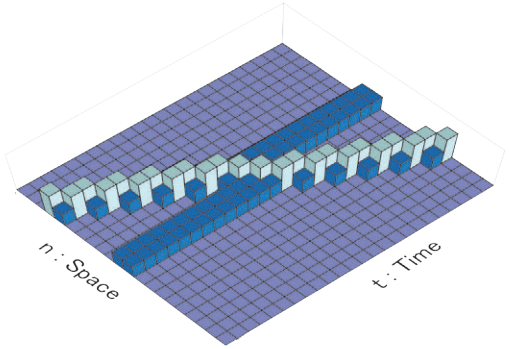
Note: Subjects marked with the letter "E" will be provided in English.

Applied Mathematical Analysis

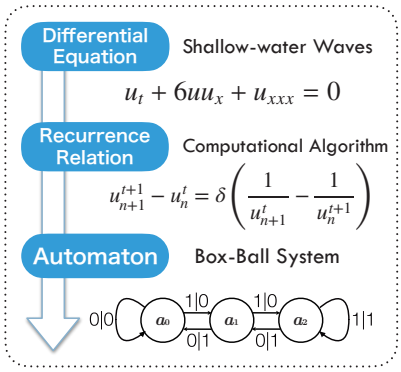
Developing algorithms from integrable systems

We carry out research in the areas of contemporary soliton research and integrable system research, not only regarding the applied analysis of orthogonal polynomials and special functions that are closely associated with integrable systems, but also regarding the application of the mathematical methods developed by integrable system studies to the solution of various problems hitherto thought to be unrelated to integrable systems (such as numerical calculation and algorithm development). Our Group is a pioneer in this research field, and conducts studies into the applied analysis of integrable systems in the development of algorithms and other new branches of mathematics from the perspective of computer science.

[Satoshi Tsujimoto]



Ultra-discrete soliton



Theory linking continuous and discrete systems, and automata

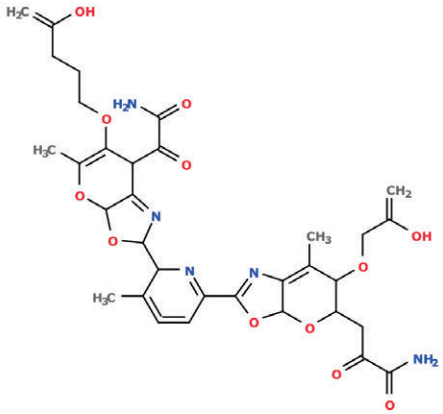
Discrete Mathematics

Exploring the complexity of discrete mathematics problems and developing algorithms

Topics in discrete mathematics, such as the graphs and networks used to represent systems, schedules to enhance the efficiency of production, and the logical analysis of large volumes of data, are closely related to applications of research results. We explore the complexity of the computation used to solve these problems; design exact and approximation algorithms; develop tabu search algorithms, genetic algorithms and other metaheuristic algorithms; and apply them to solving actual problems.

[Kazuya Haraguchi]

A puzzle in which you have to fit the pieces into a box of fixed width without any of the rectangular pieces overlapping and try to make the height of the packed pie ces as low as possible.



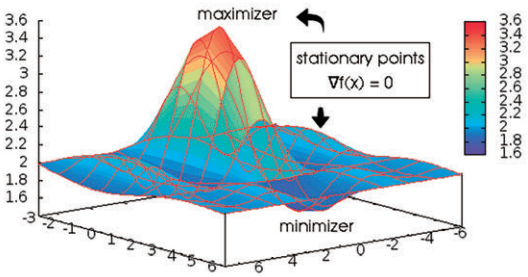
The structural formula of a compound expected to have a certain target value of heat of combustion. It was constructed by formulating and solving an inverse problem of a prediction model learned from a database of compounds in the form of a mixed-integer optimization problem.

Outline

System Optimization

Optimization is the keyword for solving problems

We conduct education and research regarding the theory and methodology of system optimization, which plays an important role as a mathematical approach that is used to resolve many different kinds of practical problems. In particular, we develop efficient mathematical optimization approaches to actual large-scale systems, complex nonlinear systems, and systems with uncertainty, as well as basic research regarding mathematical programming.



Optimal solutions of an unconstrained problem

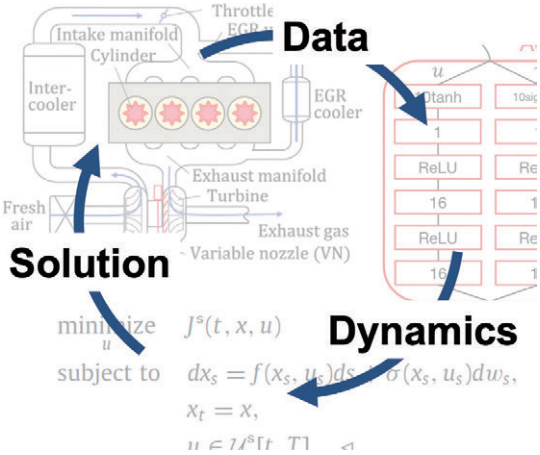
[Nobuo Yamashita , Ellen Hidemi Fukuda , Hiroyuki Sato , Yuya Yamakawa]

Control Systems theory

Mathematical approaches to modeling and control

We carry out teaching and research regarding the mathematical methodologies of modeling, analysis and design of control systems, and their application with the aim of developing practical and expansive control theories. Our main research themes are robust control, control systems with input/output constraints, networked control systems, algebraic system theory, mathematical optimization in control, stochastic realization, system identification and quantum control theory.

[Kenji Kashima , Kentaro Ohki]



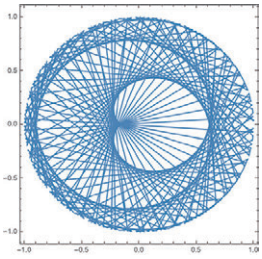
Conceptual diagram of a control system design

Physical Statistics

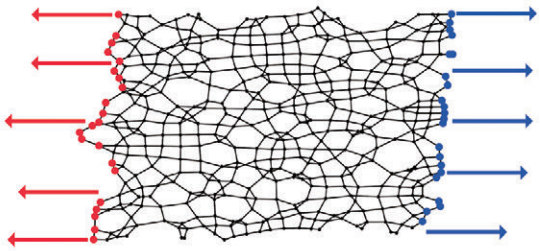
The mathematical studies on dynamics of coupled multi-element network systems and design theory of complex engineering systems

We aim to gain a mathematical and unified understanding of the complex and diverse phenomena that arise out of the intense mutual interactions of multiple elements (units) in a system and apply this understanding to information processing and design of complex engineering systems. For example, we will use stochastic process theory, ergodic theory, statistical physics, dynamical system theory, computer simulations, and large-scale data processing techniques to analyze information processing and performance evaluation in neural networks; the structure of the Internet and other complex networks such as social media systems, and the propagation of information within them; and the dynamical properties of price change, stock markets and other economic phenomena.

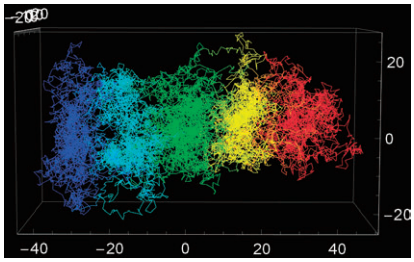
[Ken Umeno , Erika Uehara , Atsushi Iwasaki]



Chaos code for signal analysis and multiuser communications system



The distribution of vertices when a random network is extended by applying an external field to both ends of the network is computed from the graph Laplacian.



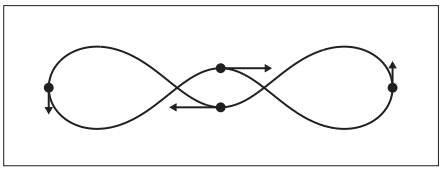
Polymer physics

Dynamical Systems

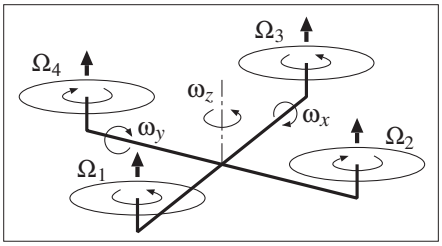
Looking into the world through dynamical systems theory

Our research purpose is to analyze complicated phenomena such as chaos and bifurcations in various systems appearing in natural science, engineering and other disciplines using dynamical systems approaches, and apply them to develop novel engineering technologies. For this purpose, we not only use standard approaches but also establish groundbreaking theories in dynamical systems. Moreover, we utilize numerical approaches such as verifiable computation rigorous numerics and large-scale numerical simulation, and study the nonintegrability of dynamical systems and differential equations, nonlinear waves in partial differential equations, periodic motions in the n-body problem of classical mechanics, several problems in the kinetic theory of many-body systems, design of spacecraft transfer trajectories, and dynamics and control of flying objects such as quadcopters.

[Kazuyuki Yagasaki , Mitsuru Shibayama , Yoshiyuki Yamaguchi]



4-body super-eight solution which is proven to exist by using variational methods



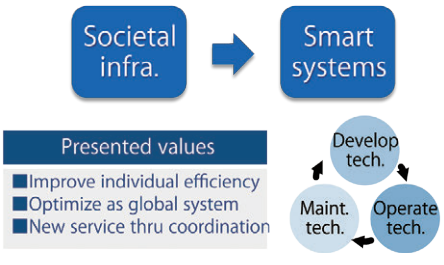
Mathematical model of a quadcopter

Applied Mathematical Modeling Adjunct Unit (In collaboration with Hitachi, Ltd.)

Infusing information systems with intelligence

To make information systems useful to our day-to-day lives and industry at large, we need to be able to mathematically model both the behavior of people and the movements of objects that these systems deal with. The form of these models ranges from the conceptual to the numerically precise. We will examine case studies from industry in our research of modeling technology, including methods of using human knowledge (structural modeling) and methods using actual data (multivariate analysis).

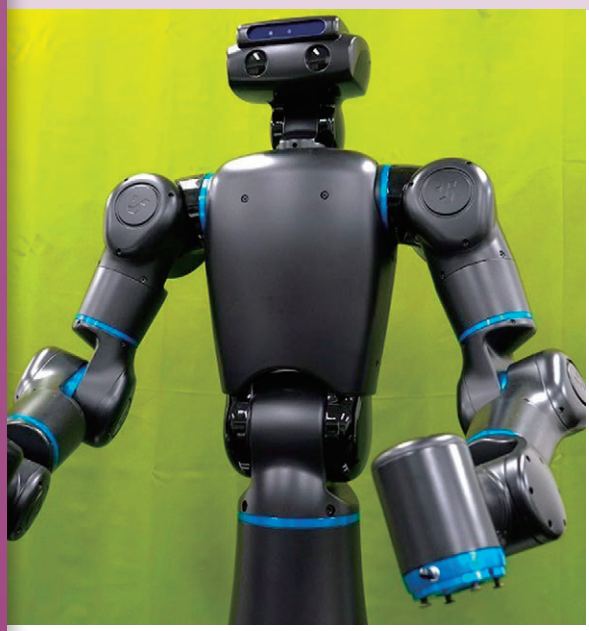
[Hitachi Ltd.: Yoichi Nonaka , Yoshiyasu Takahashi]

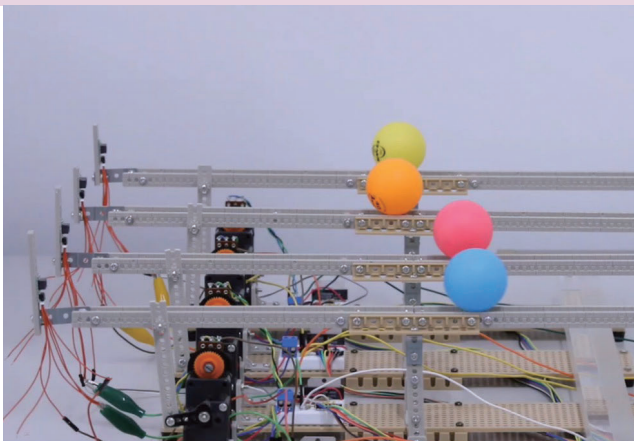


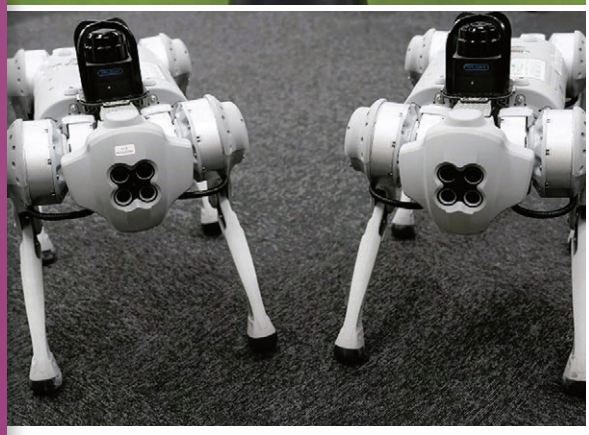
Modeling of a social infrastructure system

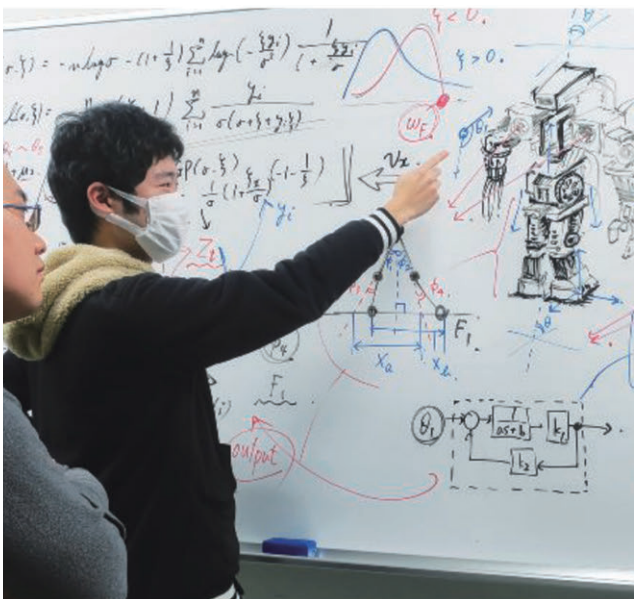
New Frontier in Informatics and Systems

Research and education in the Course of Systems Science are concerned with a new and unified approach to a variety of technological problems arising in computer communication networks, mechatronics systems, cyber-physical systems, medical information systems, and biological systems.
In particular, we are seeking theoretical methodologies applicable to these complex systems of large scales.
Emphasis is also placed upon understanding of complicated mutual interactions among human-beings, systems and environments.









Putting Information into Action

The Systems Science Course is focused on mathematically grasping common dynamic pictures of systems consisting of multiple objects, both for understanding such systems more deeply and for studying methodologies for controlling these pictures. Advances in machine learning technology and growing computational power have made it possible to use AI to generate data analysis results that include some interpretation of static data, or even to generate new data. Nevertheless, it is still a significant challenge to develop methodologies to understand and control dynamic systems in the real world from data. For example, for decision-making problems in video games or other kinds of virtual reality systems, a machine learning technique known as reinforcement learning has attracted attention by showing that it can learn from experience and acquire strategies better than humans. However, robots and other machines are still not capable of flexibly judging situations and taking responsive action like humans do in the real world. These kinds of technologies are commonly required in a wide range of other fields (aside from robots), including economics, energy, and autonomous vehicles. Students in the Systems Science Course study how information should be used for making behavioral choices and how the human brain uses the data it obtains for making decisions, and they can learn useful methodologies for understanding and applying such knowledge. The course offers a learning environment for cultivating essential insights for pursuing this kind research.

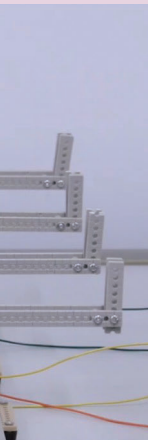
Jun Morimoto

Professor, Systems Science Course

March 2001: Received a doctoral degree from Nara Institute of Science and Technology (NAIST). April 2001: Postdoctoral Fellow, The Robotics Institute, Carnegie Mellon University. April 2008: Head of Department (concurrent position), Department of brain-robot interface, Computational Neuroscience Laboratories, Advanced Telecommunications Research Institute International (ATR), December 2019: Team Leader, Man-Machine Collaboration Research Team, Guardian Robotics Project, RIKEN. April 2021: Professor, Systems Science Course, Graduate School of Informatics, Kyoto University.

Learning"How"to Address Unknown Issues

In the Course of Systems Science, we are working on scientific research across a variety of fields. For instance, we use sensors to measure information from biological and mechanical systems in order to infer their internal states, project their future behavior, and control them. Also, by elucidating how the brain' s neural circuits process information, we are working to create a system that is capable of not only learning and making inferences but also adjusting itself to an uncertain and changing environment. Furthermore, we are studying algorithms and theory for making inferences and discoveries from the vast amount of image and document data available online and elsewhere, together with the high-performance parallel computing that makes such systems possible.



Not only are these research fields related to systems but, in many cases, research projects conducted in these fields share a common approach - researchers conduct their studies through mathematical models, constantly aware of the flow of information. Using mathematical models, researchers can treat different objects as if they were the same, thereby gaining broad perspectives.

For example, by using a "graph" that consists of vertexes and edges, researchers can express not only networks (neural networks, website link structures, railway systems, etc.) but also structures of relevant data, such as tagged images on social media. Because the objects thus modeled can be treated mathematically, scientists can advance their research even further. In the field of machine learning, significant research is being carried out into a technique called graph embedding for efficient information search. One drawback of this technique was that a graph with a hierarchical structure is not expressed very well in Euclidean space. This problem has been solved by a mathematical idea of using a curved space called "hyperbolic space."

Another characteristic of students/researchers in the Course of Systems Science is strongly conscious of systems in the real world, in addition to conducting mathematical study at an abstract level. Issues in the real world can be often solved with established methods, but very new methods occasionally arise out of addressing the challenges posed by difficulties. In the study of methodology of statistics, for instance, we are constantly exploring new ways to make inferences and predictions from data. What is important for such a situation is again knowledge in mathematical fields such as probability theory and optimization.

Thus, mathematical foundations and applications interact with each other in the Course of Systems Science. Students are invited to learn an aspect of this scientific discipline, broaden their perspectives, and acquire universal approaches and attitudes; that is, "how" to address unknown issues, through research activities and lectures at Graduate School of Informatics. We would be delighted if their experience here motivates them to address unknown issues and find clues to developing new techniques or academic disciplines.

Hidetoshi Shimodaira

Systems Science Course

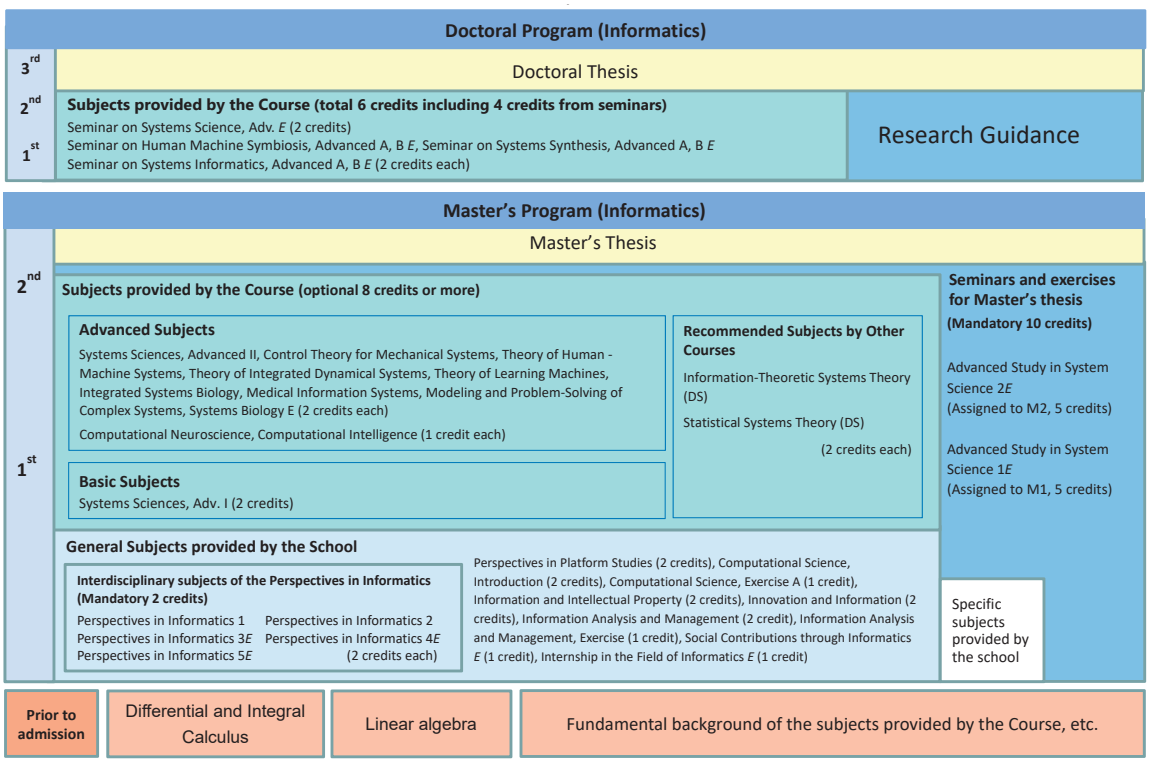
March 1990: Received a bachelor's degree from the Department of Mathematical Engineering and Information Physics, School of Engineering, The University of Tokyo. March 1995: Received a doctoral degree from the Department of Mathematical Engineering and Information Physics, Graduate School of Engineering, The University of Tokyo. April 1995: Received a Research Fellowship for Young Scientists from the Japan Society for the Promotion of Science. July 1996: Assistant Professor, Department of Prediction and Control, Institute of Statistical Mathematics. June 2002: Lecturer, Department of Mathematical and Computing Sciences, Graduate School of Information Science and Engineering, Tokyo Institute of Technology. May 2005: Associate Professor, Department of Mathematical and Computing Sciences, Graduate School of Information Science and Engineering, Tokyo Institute of Technology. April 2012: Professor, Division of Mathematical Science, Graduate School of Engineering Science, Osaka University. September 2016-present: Team Leader (concurrent position), Mathematical Statistics Team, RIKEN Center for Advanced Intelligence Project (AIP). April 2017-present: Professor, Department of Systems Science, Graduate School of Informatics, Kyoto University.

Outline

Group and Teaching Staff

Group	Teaching Staff
Mechanical Systems Control	Shun-ichi Azuma/Professor
Human Systems	Manabu Kano/Professor　Shota Kato/Assistant Professor
Integrated Dynamical Systems	Toshiyuki Ohtsuka/Professor　Kazunori Sakurama/Associate Professor Kenta Hoshino/Assistant Professor
Mobility Research	Osamu Nishihara/Associate Professor
Mathematical Information Systems	Toshiyuki Tanaka/Professor　Tomoyuki Obuchi/Associate Professor
Statistical Intelligence	Hidetoshi Shimodaira/Professor　Junya Honda/Associate Professor
Learning Machines	Jun Morimoto/Professor　Satoshi Yagi/Assistant Professor
Integrated Systems Biology	Shin Ishii/Professor　Hideaki Shimazaki/Associate Professor Paavo Parmas/Program-Specific Assistant Professor Jaepyung Hwang/Program-Specific Assistant Professor
Biomedical Engineering	Hirohiko Imai/Assistant Professor
Computational Neuroscience (Adjunct Unit)	Mitsuo Kawato /Adjunct Professor (Advanced Telecommunications Research Institute International) Takuya Isomura/Adjunct Professor　Louis Kang/Adjunct Associate Professor (RIKEN) Kenji Doya/Adjunct Professor (Okinawa Institute of Science and Technology)

Curriculum of Systems Science Course



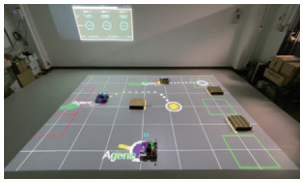
Note: Subjects marked with the letter "E" will be provided in English.

Mechanical Systems Control

Control Theory and Applications

Control theory is the academic foundation for designing the motion of dynamic systems. In this lab, we develop innovative control theory and deploy the results to leading-edge scientific and industrial applications. We also challenge ourselves to create dynamic systems that open up new possibilities for the future. Through their research activities, students cultivate the research skills needed to become a systems control leader in academia and industry.

[Shun-ichi Azuma]



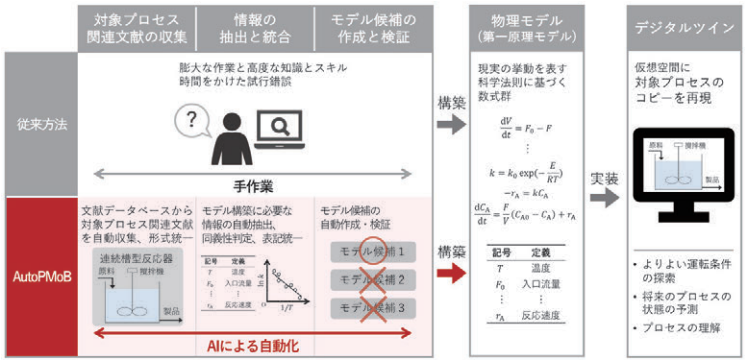
Control of conveyor robots

Control of a swarm robot system

Human Systems

Aiming to develop human-centered system design methodology

The society that values humankind is called for now. The situation is similar in the latest industrial science and technology, thus novel system design methodology is required from various positions such as those who develop technology and those who use technology. We perform basic research on developing human-centered system design methodology through understanding the mechanism of human recognition and action. In order to contribute our results to our society, we also perform applied research in various industries such as semiconductor, pharmaceutical, steel, chemical, and automobile. Furthermore, through these studies, we conduct the education that aims at training talented people to take a broad view of things and have high aims.



Development of AI for automatically developing physical models from literature information

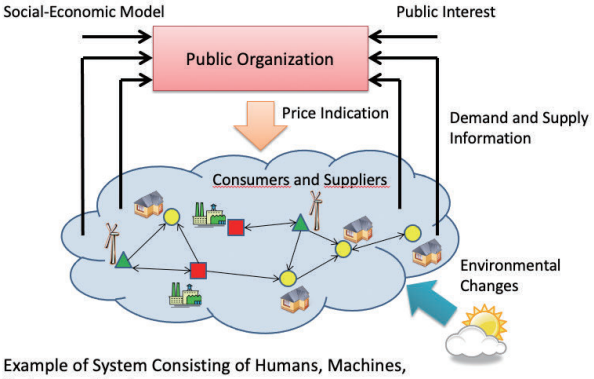
[Manabu Kano , Shota Kato]

Integrated Dynamical Systems

Toward harmonious coexistence of a diversity of systems

For analysis and design of novel systems to realize symbiosis and synergy of various objects including humans, machines, societies, and environments, it is essential to find out universal principles in modeling, analysis, design, and control of dynamical systems. To this end, we conduct researches on novel methodologies to deal with nonlinearities, uncertainties, dynamic optimization, and distributed control, which are often fundamental difficulties in various problems. We also apply our methodologies to a wide range of fields, aiming practical as well as theoretical education and research.

[Toshiyuki Ohtsuka , Kazunori Sakurama , Kenta Hoshino]



Example of System Consisting of Humans, Machines, Society, and Environment

Outline

Mobility Research

Optimizations for design and operation

The research interest of this group mostly lies in mobility technologies, such as vehicle stability controls, which have found practical applications in active safety systems for reducing car accidents, energy efficiency improvements, and collision avoidance systems. These research topics are being investigated with a view toward precise optimization within the constraints of their dynamical properties.

[Osamu Nishihara]

Mathematical Information Systems

The mathematics of large-scale probability models

We aim to develop a mathematical, cross-disciplinary understanding of a diversity of problems related to information processing under environments with uncertainty. Many problems in information processing today can be formulated with large-scale probability modeling, and using the regularities that arise thanks to the scale of these probability models is the key to achieving advanced information processing. We are working on topics in areas including statistical mechanics of information, which addresses information mathematics of large-scale probability models through analogy with statistical mechanics, and theoretical problems related to statistical machine learning, deep learning, and data science.

[Toshiyuki Tanaka , Tomoyuki Obuchi]

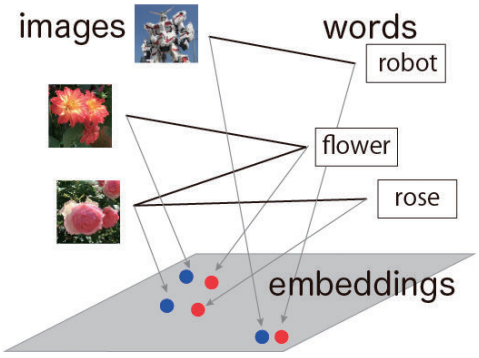
Digital communications as data science: the key to realizing high-performance digital communications lies in extracting the required information from "data" in which numerous signals interfere.

Statistical Intelligence

Statistics and machine learning: Theory and applications

Statistics is playing important roles as a theoretical framework for fast-moving fields such as big data, data mining, and artificial intelligence. Statistics provide methodologies for inductive inference from data with consideration of randomness. Recent years have seen rapid progress in machine learning, from information extraction from a massive quantity of data to decision-making with a small quantity of data, on the basis of this approach. Through addressing real-world data, we are developing new statistical methods with emphasis on mathematics and programming skills.

[Hidetoshi Shimodaira , Junya Honda]



Multiveriate analysis of multiple domains. Dimensionality reduction via graph-embeddings and bidirectional search between images and tags.

Learning Machines

Toward the realization of learning machines with bodies

The fusion field of artificial intelligence and robotics is expected to be a field that will produce the basic industrial technologies of the future. We will explore methodologies to enable machines with bodies to learn skillfully and produce desired behaviors from limited experience and data, just like humans. In order to realize learning machines that can operate in a dynamically changing open environment, we conduct education and research on basic technologies for robot motion learning methods, mathematical models of multi-degree-of-freedom robots, and human motion intention estimation.

[Jun Morimoto , Satoshi Yagi]

Robot motion learning

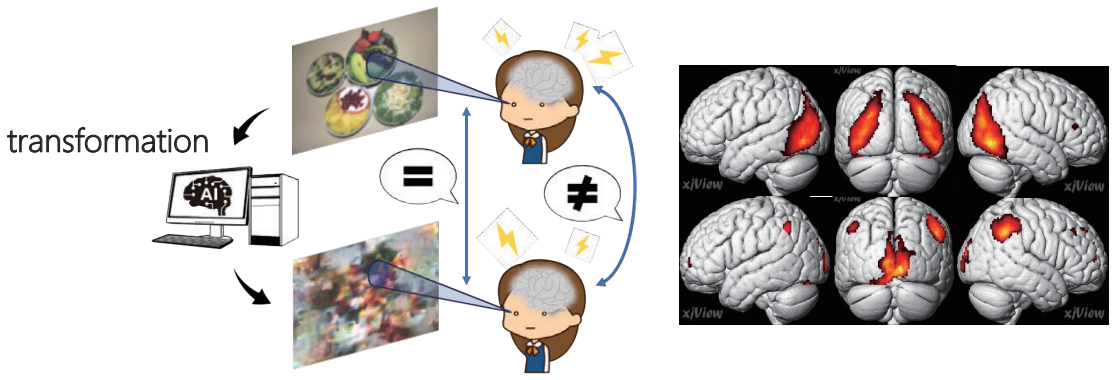
Integrated Systems Biology

Constructing models of information processing in life and intelligent systems

Intelligence (the brain) and life are complex systems that adapt to uncertain and changing environments. Aiming at elucidating the principles of information processing in those complicated systems, we are focusing on researches in the areas of computational neuroscience, systems biology, and bioinformatics, while conducting applied research, such as the application of these principles in the building of robots that have adaptive information processing mechanisms that we have learned about through our studies of living organisms.

We conduct interdisciplinary education and research on life systems.

[Shin Ishii , Hideaki Shimazaki , PARMAS Paavo, HWANG Jaepyung]



(Left) A deep learning-based image conversion technology, GAN-SID, converts "natural" images into "non-natural" images, preserving the parts that draw a person's attention (gaze)
(Right) Brain activity when viewing "natural" and "non-natural" images differs

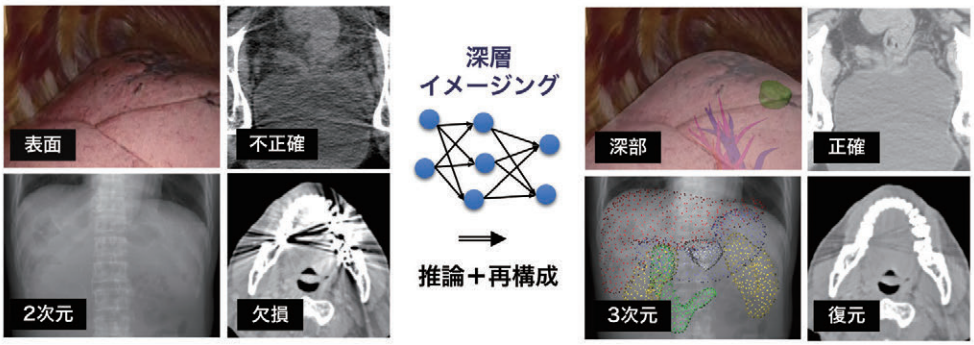
Outline

Biomedical Engineering

Learning bout the functions and physical characteristics of human bodies

Information systems such as data processing systems used in genetic analysis, diagnostic imaging systems are key technologies of modern medicine. Interdisciplinary collaboration is essential to further progress of medical systems' research that combines the two keywords of "bio" and "information." We carry out joint research projects with other research organizations in different fields including the Faculty of Medicine to develop surgical navigation systems, medical imaging techniques, and innovative methods to measure biological characteristics of human bodies.

[Hirohiko Imai]



Medical image processing and modeling for diagnosis and treatment

Computational Neuroscience Adjunct Unit (In collaboration with Advanced Telecommunications Research Institute International)

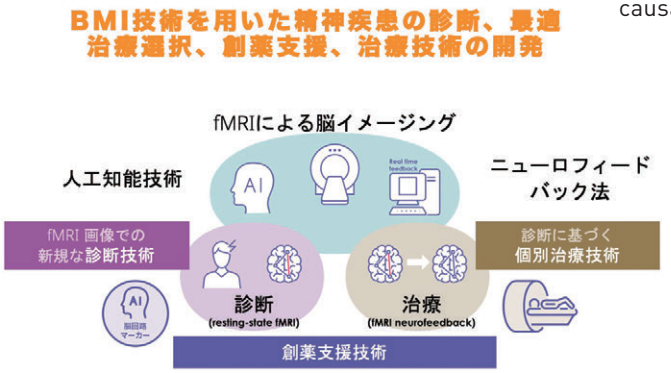
Knowing the brain by building the brain

(a) Connecting the brain and artificial intelligence

Humans and other animals are known to be capable of learning from a small sample. On the other hand, deep neural networks and other forms of current artificial intelligence today require learning samples around the same size as that of the parameters. Metacognition, multilayered generative and analytical models, and synchronization of neural activity are thought to be some of the secrets the brain holds. We aim to comprehend these and other characteristics of the brain and apply them in the development of the next generation of artificial intelligence.

(b) Brain-machine interface

Brain-machine interface technology that directly connects the human brain with machines is attracting attention as a type of "brain tech" that can improve the capabilities not only of people with impaired sensory, mobility, and central nervous functions, but also the ablebodied. Specifically, it involves a process of applying decoding techniques to non-invasively measured brain activity data, and in return providing the subject with decoded neuro-feedback that induces activity patterns in specific parts of the brain in response to certain information. The goal is to utilize this method in the treatment of psychiatric disorders and establishment of a causal approach to neuroscience.



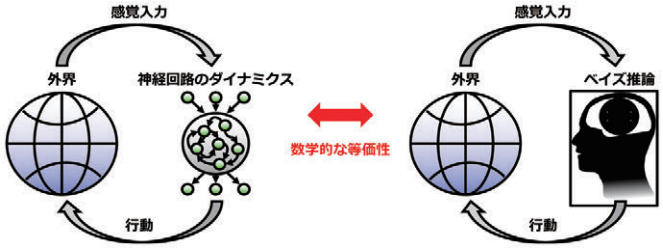
[Advanced Telecommunications Research Institute International : Mitsuo Kawato]

Computational Neuroscience Adjunct Unit (In collaboration with RIKEN)

Exploring the mechanism for emergence of intelligence from neural circuits

How do the neural cells and synaptic couplings that constitute the brain achieve the kind of superior intelligence we find in living creatures? With a view to solving this mystery, we apply mathematical approaches such as dynamic theory, Bayesian statistics, machine learning, and the free energy principle to construct a universal theory of the brain. We focus particularly on topics such as internal model learning in the cerebral cortex and the mechanisms of memory and spatial awareness in the hippocampus. We aim to apply our findings in the development of new artificial intelligence algorithms, psychiatric disorder models and the like.

[RIKEN: Takuya Isomura, Louis Kang]



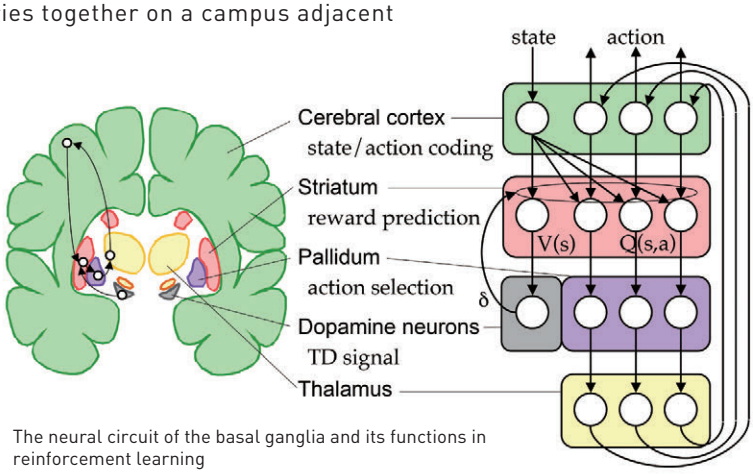
Neural circuit dynamics and plasticity potentially apply Bayesian inference

Computational Neuroscience Adjunct Unit (In collaboration with Okinawa Institute of Science and Technology)

Shedding light on the computational theories of action learning and the learning systems of the brain

Humans and other animals can acquire new behaviors in line with various environments. What workings of the brain enable such acquisition? Answering this question requires a complementary approach to developing computational theories and algorithms on action learning in diverse environments and explicating the mechanisms of neural cells and molecular networks in the brain. Our lab brings researchers from a variety of different fields and countries together on a campus adjacent to the ocean in Okinawa to pursue research on topics including development of new algorithms for reinforcement learning and Bayesian inference, using those algorithms in action learning by robots and applications to bioinformatics, experiments in measurement and control of activity in the cerebral cortex, basal ganglia, and serotonin neurons of rats and mice, explication of human action learning and brain activity, and evolution of group behavior objectives and learning processes in robots.

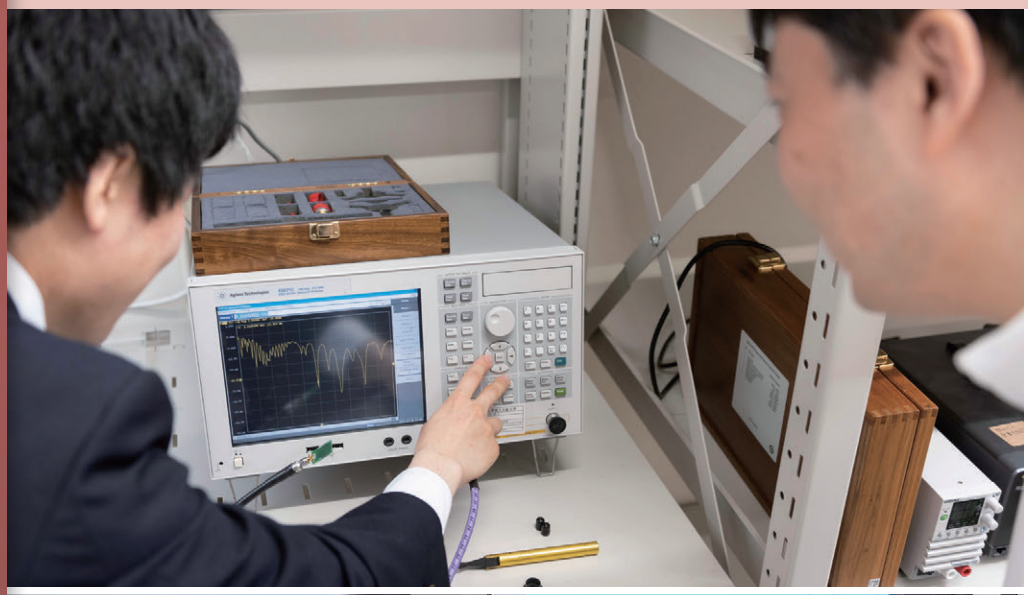
[Okinawa Institute of Science and Technology: Kenji Doya]

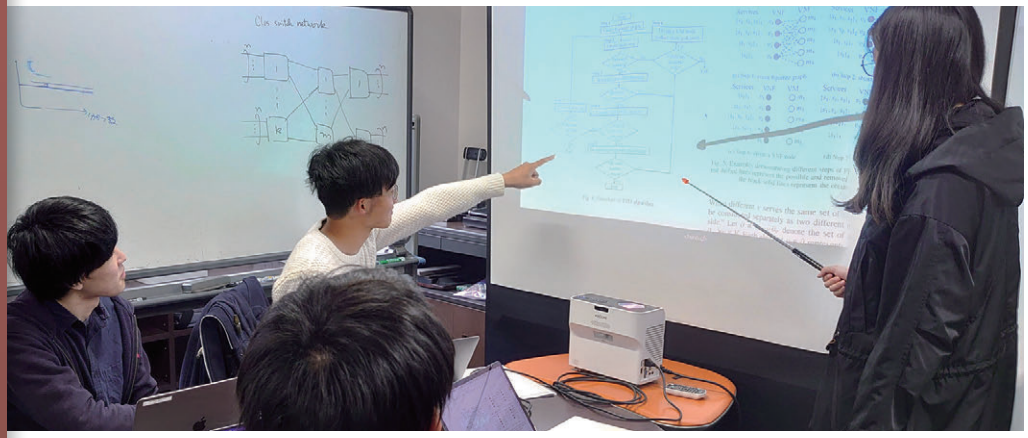


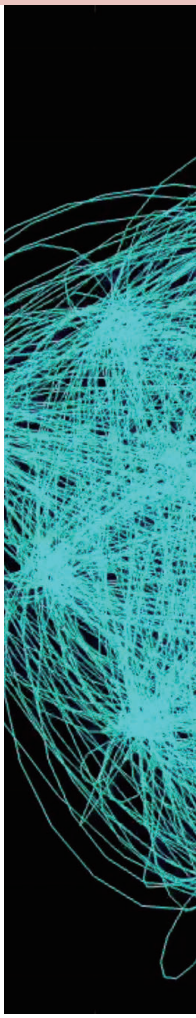
The neural circuit of the basal ganglia and its functions in reinforcement learning

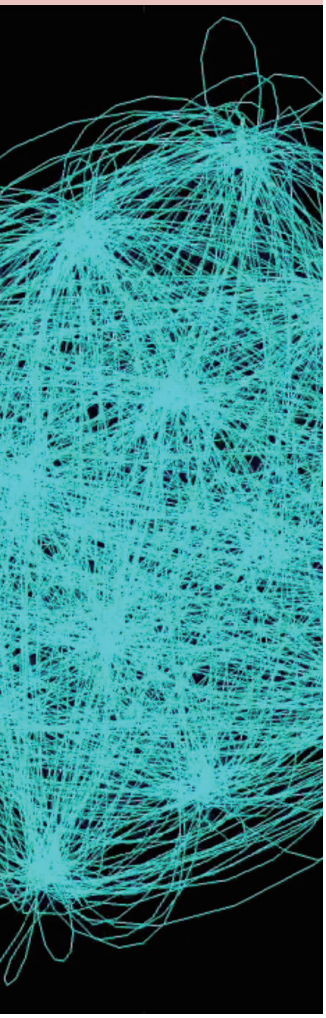
Towards the Establishment of Fundamental Technologies in the Information Age

Advanced information processing and communications are indispensable for our society to prosper in the 21st century.
Information processing devices typified by computers are called upon to achieve high performance and be highly functional and compact.
In communications, we should be able to enjoy high-speed, reliable transmission of a vast amount of multimedia data anytime, anywhere.
The Course of Communications and Computer Engineering supports the development of future technologies in the fields of information processing devices and digital communications.









Constructing Information and Communication Infrastructure for an Innovative Society

Dramatic changes in socioeconomic conditions and globalization have given rise to a mountain of new and increasingly complex social challenges involving multiple different domains and fields. To address these challenges, information and communication "platforms" that take advantage of real-time data from the real (physical) world, as well as massive quantities of accumulated data from the virtual (cyber) space of servers and clouds are being used.

This information and communication infrastructure will generate new value and resolve social issues by using various sensing technologies to collect different kinds of information that are ubiquitous in the physical world, storing this information in cyberspace over a wide area using communication technologies, and then processing it using information technologies for data organization, analysis, feature extraction, and prediction, and finally, feeding the results of processing back into the physical world using communication technologies to share the results for a variety of purposes.

This kind of infrastructure requires various kinds of devices built from integrated circuits, taking into consideration size and power consumption to enable high-speed data collection and processing, computers (hardware and software) for high-speed, high-efficiency processing of data stored in virtual spaces, and a communication system that can reliably connect an extremely large number of devices across cyberspace at high speed. The R&D on these devices, computers, and communication systems needs to be integrated, rather than conducted separately.

The Communication and Computer Engineering Course provides education and research on computers, communications, and integrated systems, the fundamental technologies for building this platform, all within a single course. Research findings in this field are at the forefront of shaping the world, as they are implemented in Japan and internationally through joint research with industry, international standardization, and other means, to support a wide range of social and economic systems. Come to study with us in the Communications and Computer Engineering Course and help to generate new value for the benefit of society, through innovations in essential information and communication technologies and systems.

Hiroshi Harada

Professor, Communications and Computer Engineering Course

He received his Ph.D. degree from the Graduate School of Engineering, Osaka University in 1995. He joined the Communications Research Laboratory, Ministry of Posts and Communications, (currently National Institute of Information and Communications Technology: NICT). After working as a researcher at Delft University of Technology, the Netherlands, a research manager and research director at NICT, and laboratory director at the Singapore Laboratory of NICT, he became a professor at Graduate School of Informatics, Kyoto University in 2014. Since 1995, he has been involved in the research, development, international standardization, and commercialization of mobile wireless communication systems and wireless communication systems for the Internet of Things.
He received the Commendation for Science and Technology from the Minister of Education, Culture, Sports, Science and Technology in 2014, the Achievement Awards from IEICE in 2006 and 2018, and the Working Group Chair Awards from IEEE Standard Association for the contributions of five international standards on wireless communication

Outline

Group and Teaching Staff

Group	Teaching Staff
Computer Algorithms	Shin-ichi Minato/Professor Jun Kawahara/Associate Professor Jesper Jansson/Associate Professor Yuni Iwamasa/Assistant Professor
Computer Architecture	Naofumi Takagi/Professor Ryota Yasudo/Assistant Professor
Computer Software	Atsushi Igarashi/Professor Kohei Suenaga/Associate Professor Masaki Waga/Assistant Professor Mirai Ikebuchi/Assistant Professor
Digital Communications	Hiroshi Harada/Professor Keiichi Mizutani/Associate Professor Yusuke Koda/Assistant Professor
Integrated-Media Communications	
Intelligent Communication Networks	Eiji Oki/Professor Takehiro Sato/Associate Professor Ryuta Shiraki/Assistant Professor
Processor Architecture and Systems Synthesis	Takashi Sato/Professor Hiromitsu Awano/Associate Professor
Integrated Circuits Design Engineering	Kiichi Niitsu/Professor
Advanced Signal Processing	Masatoshi Hashimoto/Professor Ryo Shirai/Assistant Professor
Remote Sensing Engineering	Mamoru Yamamoto/Professor Tatsuhiro Yokoyama/Associate Professor
Atmospheric Observations	Hiroyuki Hashiguchi/Professor Koji Nishimura/Associate Professor
Supercomputing	Keiichiro Fukazawa/Associate Professor
Multimedia and Secure Networking	Yasuo Okabe/Professor Daisuke Kotani/Assistant Professor

Curriculum of Communications and Computer Engineering Course

Doctoral Program (Informatics)

3rd: Doctoral Thesis

2nd / 1st: **Subjects provided by the Course (total 6 credits including 4 credits from seminars)**
Seminar on Communications and Computer Engineering, Adv. A, B *E* (1 credit each)
Seminar on Computer Engineering, Adv. A, B *E*, Seminar on Communication Systems Engineering, Adv. A, B *E*, Seminar on Integrated Systems Engineering, Adv. A, B *E*, Seminar on Radio Atmospheric Science, Adv. A, B *E*, Seminar on Communication and Computer System, Adv. A, B *E* (2 credits each)

Research Guidance

Master's Program (Informatics)

Master's Thesis

2nd / 1st: **Subjects provided by the Course (optional 12 credits or more, including recommended subjects provided by other Courses)**

Advanced Subjects
Design in ICT, Theory of Computational Complexity *E*, Parallel Computer Architecture, Hardware Algorithm, System Verification *E*, Formal Semantics of Computer Programs, Transmission Media Engineering, Adv., Integrated System Architecture and Synthesis, System-Level Design Methodology for SoCs *E*, Atmospheric Measurement Techniques *E*, Remote Sensing Engineering, Computer Network, Advanced, Supercomputing, Advanced (2 credits each)

Basic Subjects
Theory of Discrete Algorithms, Introduction to Algorithms and Informatics, Digital Communications Engineering, Information Networks, Integrated Circuits Engineering, Adv. (2 credits each)

Recommended subjects provided by other Course (4 credits, Mandatory)
Language Information Processing, Adv. *E* (IST), Biosphere Informatics *E* (SI)
Cryptography and Information Society (SI) (2 credits each)

General Subjects provided by the school

Interdisciplinary subjects of the Perspectives in Informatics (Mandatory 2 credits or more, up to 4 credits)
Perspectives in Informatics 1 Perspectives in Informatics 2
Perspectives in Informatics 3*E* Perspectives in Informatics 4*E*
Perspectives in Informatics 5*E* (2 credits each)

Perspectives in Platform Studies (2 credits), Computational Science, Introduction (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credit), Information Analysis and Management, Exercise (1 credit), Social Contributions through Informatics *E* (1 credit), Internship in the Field of Informatics *E* (1 credit)

Seminars and exercises for Master's thesis (Mandatory 10 credits)
Advanced Study in Communications and Computer Engineering 2*E* (Assigned to M2, 5 credits)
Advanced Study in Communications and Computer Engineering 1*E* (Assigned to M1, 5 credits

Specific Subjects provided by the school

Prior to admission: Communications and Radio Engineering | Logic and Integrated Circuits Engineering | Computer Engineering | Theoretical Computer Science — Required to earn more than 2 credits from the four subjects on the left

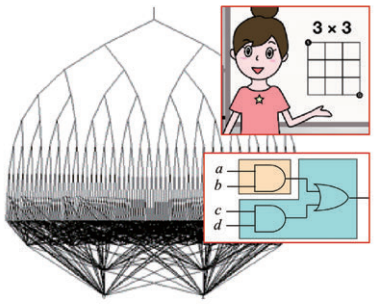
Note: Subjects marked with the letter "E" will be provided in English.

Computer Algorithms

The theory and art of algorithms, with real-life applications

A computer system consists of hardware and software. Both parts work according to a logical procedure: "algorithm." The art of algorithms and complexity theory are core areas in computer science, and needless to say have a multitude of applications. We investigate fundamental theory, state-of-the-art techniques, and real-life applications of "algorithms," a keyword of our laboratory. We aim to enable computers to make increasingly significant contributions to society.

[Shin-ichi Minato , Jun Kawahara , Jesper Jansson , Yuni Iwamasa]

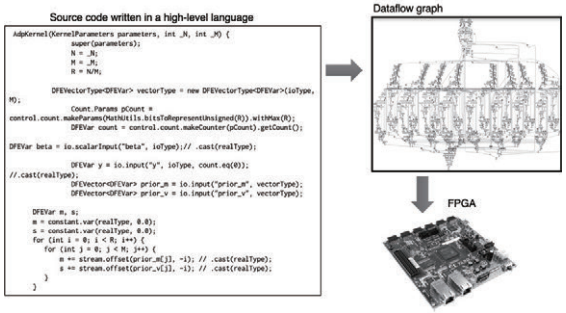


Computer Archtecture

Advanced computing mechanisms and design technologies

We conduct education and research on new computing mechanisms and their design technologies for the post-Moore era in which exponential improvement in computer performance is difficult to achieve. Our main research topics include computing methods utilizing FPGA which is a reconfigurable hardware and GPU which enables high-speed parallel computing, high-capacity memory systems based on packet transfer, systems for uniform handling of combinational optimization, and design of superconductive digital circuits and development of their design support technologies.

[Naofumi Takagi , Ryota Yasudo]



Computer Software

Theory and practice for efficient and dependable software

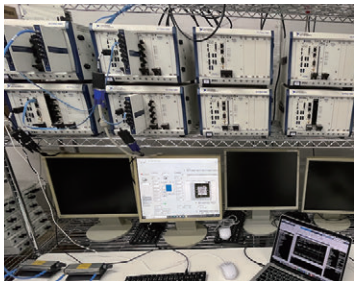
Centering around programming languages, we conduct research and education on theory and practice for building highly efficient and dependable software. Our main focuses are on theory of program verification techniques based on mathematical logic, such as type theory and model checking, and the design and implementation of high-level programming languages, backed by rigorous foundations.

[Atsushi Igarashi , Kohei Suenaga , Masaki Waga , Mirai Ikebuchi]

Outline

Digital Communications

Toward ubiquitous wireless information networks



Wireless communication networks, accelerated by cellular radio together with short-range wireless communications and RFID tag technologies, for instance, have been advancing significantly towards the goal of so-called ubiquitous networks. That is, we are on the verge of an era when people can enjoy various benefits unconsciously from totally connected network where various equipments, devices, and sensors are closely connected each other and linked to the Internet via wireless technologies. With wireless distributed self-organizing information networks which will be expected to play core roles in such a next generation information networks in mind, we are actively working to conduct education and research on highly efficient radio resource management techniques including spectrum sharing among multiple wireless systems, and highly spectrum- efficient signal processing techniques for broadband wireless transmission, etc.

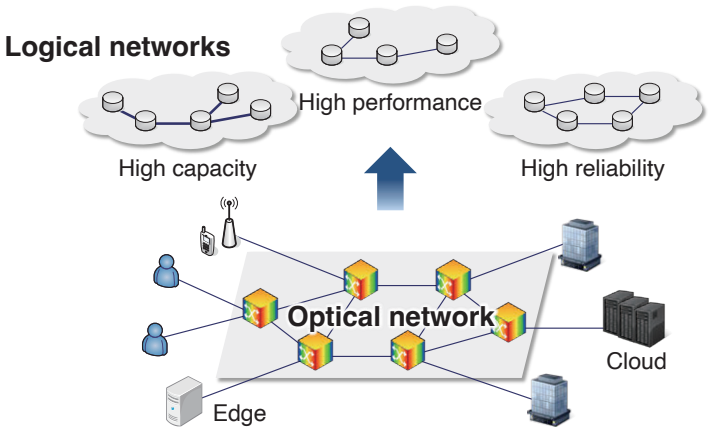
[Hiroshi Harada , Keiichi Mizutani , Yusuke Koda]

Intelligent Communication Networks

Exploring information and communication network paradigms

The advancement of the Internet of Things (IoT) and big data technologies has enabled the networking of all types of devices around us and the provision of a diverse variety of services through data processing on cloud and edge platforms. Establishing these types of systems as social infrastructure will require technologies for the sophisticated design and control of networks for the transmission and reception of large volumes of traffic and computer resources to collect and analyze data. Our laboratory conducts research on high-speed, reliable, and flexible information communication networks using a broad range of theoretical and practical approaches.

[Eiji Oki , Takehiro Sato , Ryuta Shiraki]



Processor Architecture and Systems synthesis

Architecture design methodology for system LSIs

Architecture design of integrated circuits is a key enabler for exploiting full potential of advance semiconductor technologies. Real-time signal processing on media data, extremely low power operation to prolong battery lifetime, and maximizing reliability of the system are of utmost importance. We conduct researches on the following areas: (1) methodologies for circuit analysis, circuit design techniques, and circuit-performance optimization, (2) architectural design for processors and reconfigurable devices for system LSI, and (3) hardware and embedded software algorithms for codecs, digital communications, image recognition, and their design methodologies.

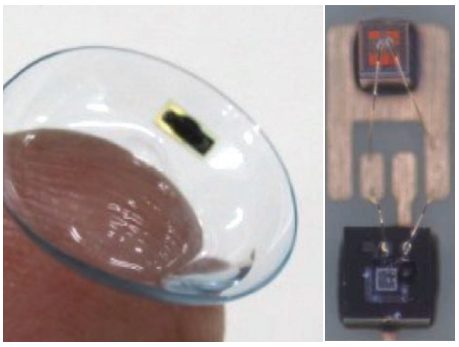
[Takashi Sato , Hiromitsu Awano]

Integrated Circuits Design Engineering

Circuit and Design Technologies for Large-Scale, High-Performance CMOS LSIs

Large-scale integrated (LSI) circuit systems are now essential elements of the public infrastructure that supports our modern information society. Our focus is doing fundamental R&D on design technology for energy-efficient semiconductor LSI circuits and developing new applications for them. Our approach is to envision a finished product, as well as the services in which it will be utilized, and even the social impact of those services, and then design and develop the high-energy efficiency LSI circuits to enable that product. Our R&D work ranges widely, from drawing up public acceptance scenarios to formulating necessary LSI circuit specifications, trial manufacturing of ICs, and creating prototypes in a consistent manner.

[Kiichi Niitu]



Power-independent continuous blood glucose monitor contact equipped with 65 nm CMOS IC and glucose power element

Ultrafast Signal Processing

Design and application of integrated systems

Our society is increasingly dependent on information system infrastructures, such as AI and Internet of Things (IoT). As they deal with human lives and property, information systems are required to offer high reliability. Ultra-low power, ultra-small volume semiconductor devices have been made possible by miniaturized transistors, and are realizing ambient computing that blends in with the environment. On the other hand, as the miniaturization of transistors seems to have reached its limit, efforts are underway to seek computing based on new principles. Under the banner of "creating computing infrastructure," this group is seeking ways to design reliable, high-performance computers, realize next-generation computing based on new principles, and define a computing system that changes our lifestyles.

[Masanori Hashimoto , Ryo Shirai]

Experiment to evaluate the reliability of an integrated system against cosmic rays

Outline

Remote Sensing Engineering

Exploration of the Earth's atmosphere through radars

We aim to elucidate various phenomena observed in the Earth's atmosphere, through the development of radio remote sensing and computer modeling. We are developing radar technology and/or simulation codes for studying various atmospheric phenomena (e.g., turbulence, rain, clouds, plasma) over a wide altitude range -- from phenomena that occur near the surface and hence are directly related to human activities, to phenomena that occur at the ionosphere above 100 km altitude, which is the boundary between the atmosphere and space. We study phenomena over Japan by the MU radar, and focus on the atmospheric and space weather phenomena. In addition to an atmospheric radar located in Indonesia (Equatorial Atmosphere Radar; EAR), we deploy an observation network in Southeast Asia under international collaboration in order to understand the atmospheric/ionospheric phenomena near the equator, where deep cumulus convection is moreprevalent there than anywhere else.

[Mamoru Yamamoto , Tatsuhiro Yokoyama]

Equatorial Atmosphere Radar in West Sumatra, Indonesia. Its size is about the same as that of the MU radar.

Atmospheric Observations

Towards developing new observation techniques to obtain atmospheric environmental information

We are developing new techniques to observe the atmosphere using radio waves, light, and acoustic waves, and conduct research and education to collect, process, and disseminate global observational atmospheric data. More specifically, our research topics include profiling of atmospheric temperature and humidity by using radio-acoustic sounding and laser radar techniques, development of radar digital receivers using software-defined radio for radar imaging observations of atmospheric turbulence, and development of adaptive clutter suppression techniques using the MU radar. We also carry out atmospheric observations around the world and combine a variety of techniques such as satellite data analysis and numerical modeling in order to elucidate various phenomena of the Earth's atmosphere, which is a protective coat of the humanosphere.

[Hiroyuki Hashiguchi , Koji Nishimura]

MU radar in Shigaraki, Koka City , Shiga Prefecture. The diameter of the antenna is 103 m.

Supercomputing

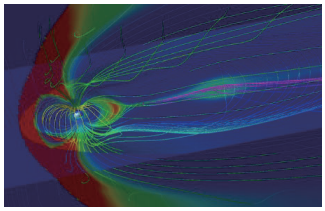
Aiming to be at the forefront of computing performance

We are involved in research into supercomputers, their software, and systems that are thousands or tens of thousands of times more powerful than ordinary personal computers.

Our focus is on research related to fundamental technologies to support future high-performance parallel computing, such as high-performance and highly parallel program development techniques suitable for state-of-the-art processors and computers, research on program scheduling to maximize the computing performance per unit of power consumption, and development of applications that can take advantage of supercomputers. Much of this research is in the form of joint research projects that extend beyond the field of computer science to involve researchers in the fields of medicine, physics, engineering, and other areas.

[Keiichiro Fukazawa]

Supercomputer at the Academic Center for Computing and Media Studies



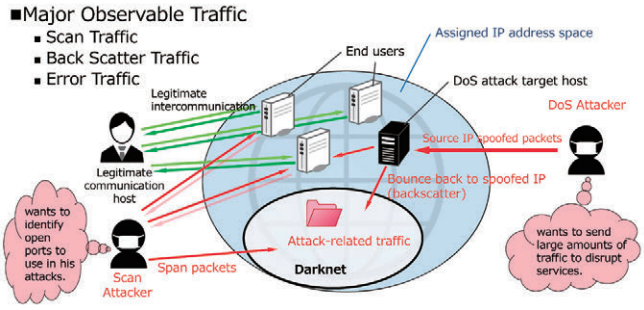
Global magnetosphere simulation using massively parallel computing

Multimedia and Secure Networking

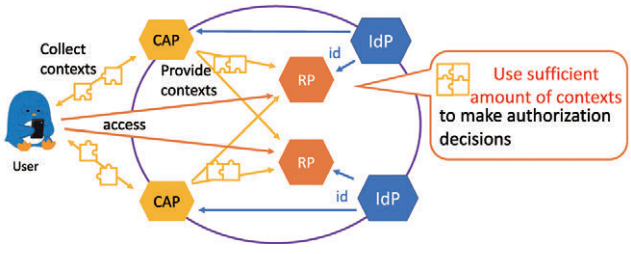
Towards a ubiquitous networking world

Society 5.0 is a vision of a future society in which computers and network functions are embedded into everything, characterized by a high degree of integration between cyberspace and physical space through "anytime, anywhere" network connections. As fundamental technologies to support this kind of society, we are pursuing research on next-generation Internet technologies such as programmable networks and protocols that use such networks, operational technologies such as automated configuration, platform technologies that support assorted services such as identity federation, and security. As the network research division of the Academic Center for Computing and Media Studies, we also perform numerous empirical studies using operational networks, both on and off campus.

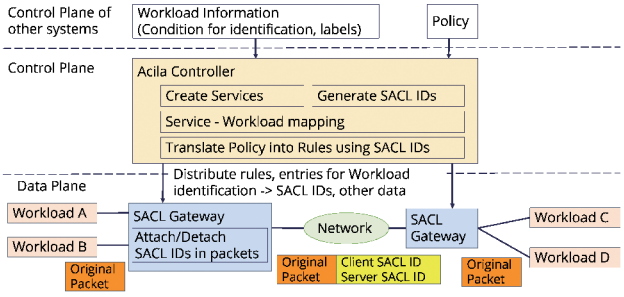
[Yasuo Okabe , Daisuke Kotani]



Investigating cyberattack trends by observing darknets (unused IP address spaces)



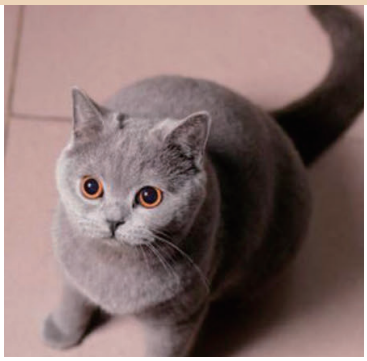
Linking contextual information suitable for identity federation in a Zero Trust system

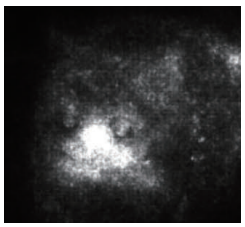


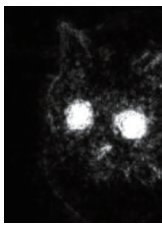
Network access control using workload identities for cloud operations

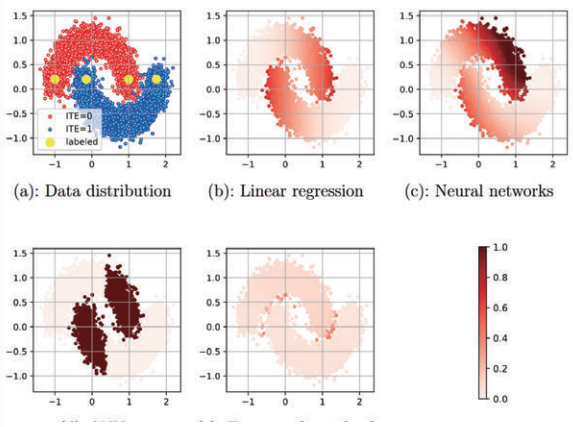
Data Science and Beyond

Data science has become very important in recent years as a methodology for inductively constructing models and hypotheses from data.
This trend has also spilled over into other academic disciplines, such as medicine, education, disaster prevention, agriculture, economics, and linguistics, leading to a surge in demand for data scientists in industries spanning agriculture and manufacturing, distribution and retailing, and finance and entertainment. The new Data Science Course, established in April 2023 as a center for education and research in mathematics, data science, and machine learning, also serves to foster top-class data science experts.
By actively welcoming students and researchers from adjacent disciplines, we also contribute to the creation of new interdisciplinary academic fields.

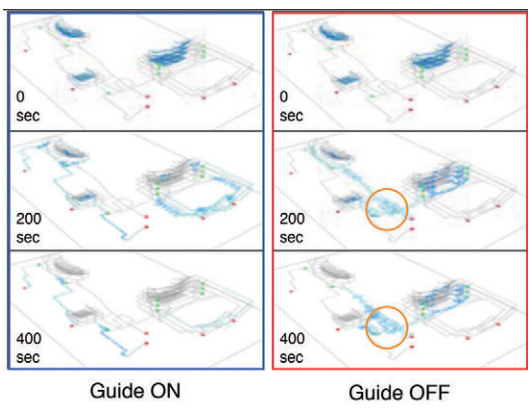




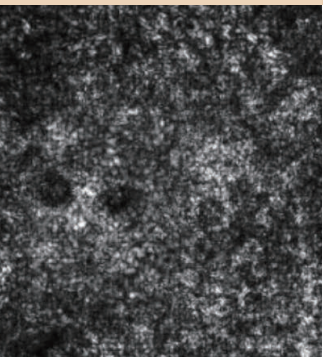


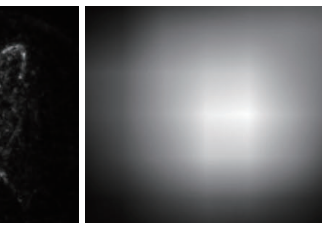


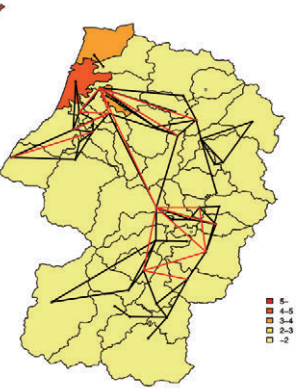
(a): Data distribution (b): Linear regression (c): Neural networks



Guide ON Guide OFF







Data Science is Drawing a Lot of Attention

Thanks to advances in information and communication technologies, a wide variety of data are now being collected and stored on an unprecedented scale. A lot of efforts are also being made in trying to inductively draw out knowledge from such data. Various new developments are also emerging in statistical and machine learning theories, which serve as frameworks to support the process of inductive inference from data. Such advances are making it possible to systematically deal with types of data that were previously difficult to handle, as well as to perform new types of data analysis. Then there is deep learning. Starting with images and text, varieties of data that are being accumulated in massive quantities, models with superior capabilities that can be mistaken as the artificial "intelligence" have now been constructed for different tasks, by appropriately training multilayer neural networks. These striking achievements in deep learning have in turn been raising new questions about frameworks for making inductive inferences from data. Why does deep learning work so well? According to optimization theory, it should be difficult to optimize the kind of non-convex objective functions that typically appear in deep learning. Statistical learning theory also states that complex models, such as multilayer neural networks, cannot be expected to have a good generalization ability. In the light of these findings, it is hard to explain why deep learning works so effectively. In the search for an answer to this conundrum, new systems and methodologies of deep learning, and by extension, data science, are likely to emerge.

We invite you to dive with us into this exciting world of data science.

Toshiyuki Tanaka

Data Science Course

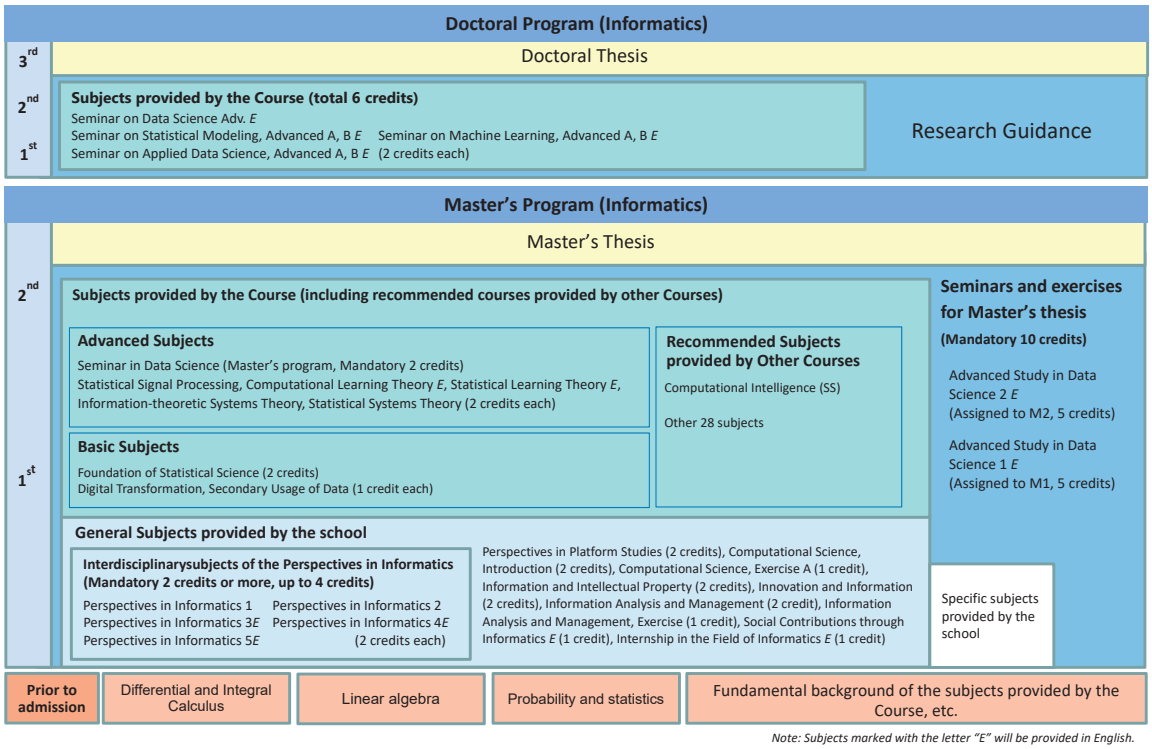
March 1993: Received a doctoral degree from the University of Tokyo. April 1993: Assistant, Department of Electronics Engineering, Faculty of Technology, Tokyo Metropolitan University. April 2000: Lecturer, Department of Electrical Engineering, Graduate School of Engineering, Tokyo Metropolitan University. January 2002: Associate Professor, Department of Electrical Engineering, Graduate School of Engineering, Tokyo Metropolitan University. April 2005: Associate Professor, Department of System Design, Faculty of System Design, Tokyo Metropolitan University. October 2005: Professor, Department of Systems Science, Graduate School of Informatics, Kyoto University.

Outline

Group and Teaching Staff

Group	Teaching Staff
Statistical Mathematics	Hidetoshi Shimodaira/Professor　Junya Honda/Associate Professor
Statistical Inference	Hisayuki Hara/Professor (Secondary appointment : Institute of Liberal Arts and Sciences)
Information-Theoretic Learning	Toshiyuki Tanaka/Professor　Tomoyuki Obuchi/Associate Professor
Signal and Information Processing	Kazunori Hayashi/Professor (Secondary appointment : Institute of Liberal Arts and Sciences)
Applied Machine Learning (Computational Intelligence)	Akihiro Yamamoto/Professor　Ichigaku Takigawa/Program-Specific Professor Brendan John Flanagan /Program-Specific Associate Professor(Institute of Liberal Arts and Sciences)
Applied Machine Learning (Collective Intelligence)	Hisashi Kashima/Professor　Koh Takeuchi/Assistant Professor
Medical and Healthcare Data Science	Hiroshi Tamura/Professor (Secondary appointment : Institute of Liberal Arts and Sciences)
Computational Intelligence Systems (Adjunct unit)	Toshiyuki Tanaka/Professor　Nonori Ueda/Adjunct Professor Tomoharu Iwata/Adjunct Teaching Staff (NTT Communication Science Laboratories)

Curriculum of Data Science Course



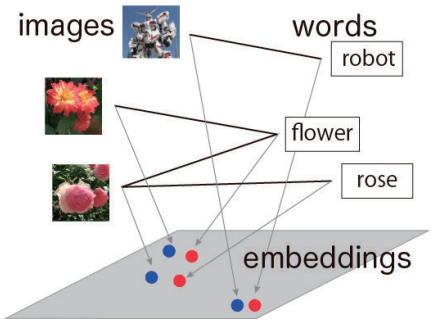
Note: Subjects marked with the letter "E" will be provided in English.

Statistical Mathematics

Theory and Application of Statistics and Machine Learning

Statistics plays a vital role as the theoretical foundation of the highly influential trends of big data, data mining, and AI. A key feature of statistics is that it provides a methodology for making inductive inferences from data, in a way that accounts for randomness. On this foundation, machine learning has developed very rapidly in recent years, from extracting information from large volumes of data to making decisions utilizing only small amounts of data. Our aim at this turning point is to develop new methodologies driven by mathematics and programming to use with real-world data.

[Hidetoshi Shimodaira , Junya Honda]



Graph embedding using neural nets to reduce the dimensionality of data and perform image-text mutual search.

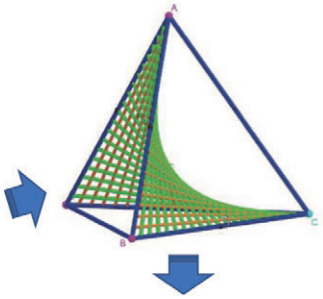
Statistical Inference

Mathematics of Statistical Inference in the Age of Big Data and Its Applications

With the rise of big data, machine learning, and AI, statistical inference theory and algorithms for statistical inference in high-dimensional complex systems are increasingly important. Although massive quantities of data are now readily accessible, the complexity of the phenomena we want to understand clearly remains daunting. It is therefore necessary to develop robust inference methods that allow us to make reliable inferences using even small sample sizes. Our research and education are focused on the development of high-dimensional inference methods and their application to fields as diverse as archaeology, anthropology, and cognitive science, by making use not only of classical inference methods but also various mathematical techniques such as combinatorics, algebraic geometry, and optimization methods.

[Hisayuki Hara]

	1	2
1	x_{11}	x_{12}
2	x_{21}	x_{22}



$$p_{11}p_{22} - p_{12}p_{21} = 0 \qquad p_{11}^{x_{11}}p_{22}^{x_{22}} - p_{12}^{x_{12}}p_{21}^{x_{22}} = 0$$

Many statistical models can be interpreted as algebraic varieties.
Algebraic quantities can offer valuable insights for statistical inference.

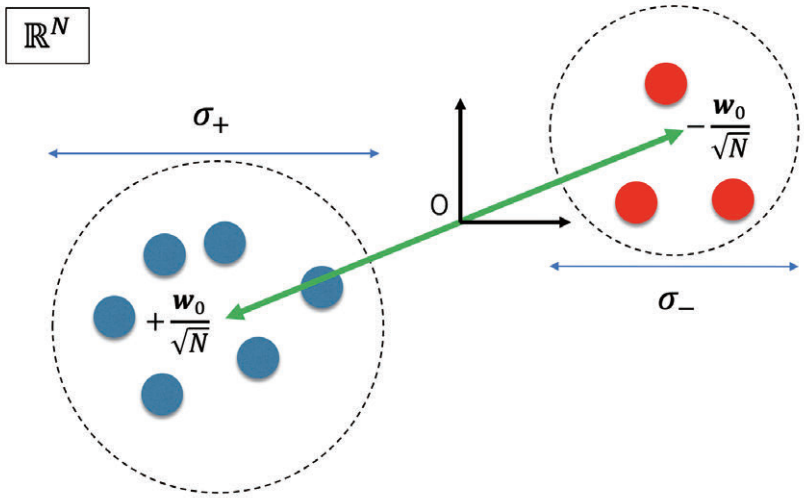
Outline

Information-Theoretic Learning

Information Mathematics for Machine Learning

Over recent years, deep learning has advanced enormously, with a rich variety of ideas and models generated and proposed. In addition to deep learning, other methods of machine learning have also been developed for dealing with various challenges confronted in data science. In some cases, the reasons why such methods are effective or the properties of such methods are not even understood. Our aim is to shed light on the mechanisms of these methods via utilizing knowledge from information theory and the statistical mechanics of disordered systems.

[Toshiyuki Tanaka, Tomoyuki Obuchi]

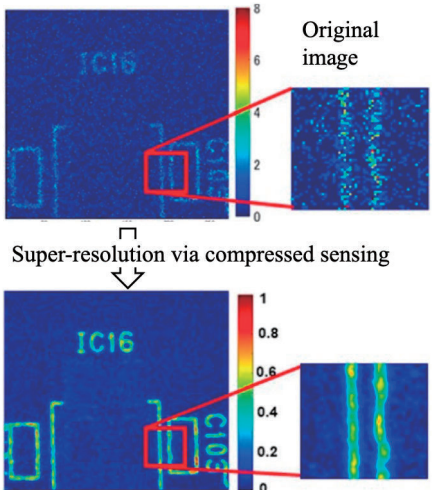


Signal and Information Processing

Stochastic and Statistical Approaches for Understanding Mathematical Systems

Our focus in this field of signal information processing is on the construction and the analysis of mathematical models for stochastic and statistical problems that emerge in various kinds of systems, and on the development of effective algorithms for practical application of such models. More specifically, we are making use of statistical signal processing, an approach to systematizing methodologies for extracting useful information from observed raw signals and data, as a tool for tackling problems mainly in communications systems, such as mobile communications, optical fiber communications, and IoT.

[Kazunori Hayashi]



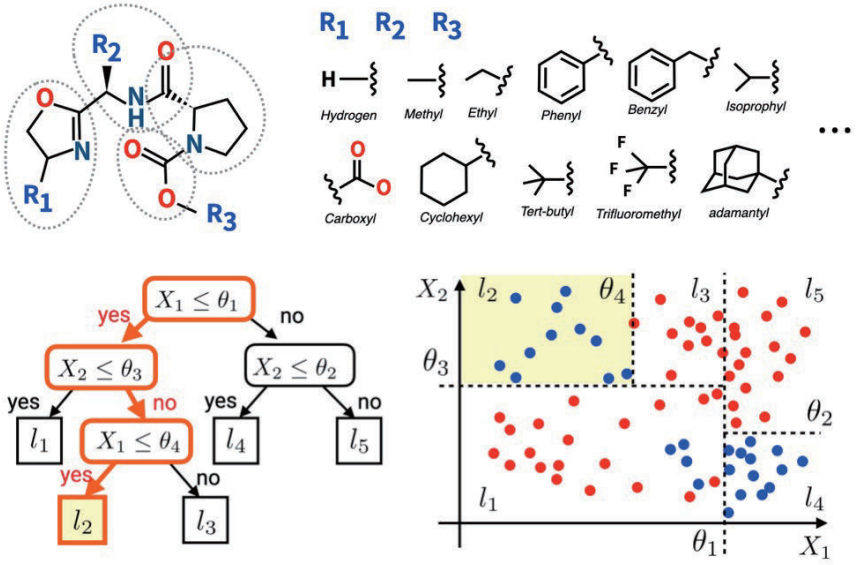
Example of super-resolution image by compressed sensing for X-ray fluorescence measurement

Applied Machine Learning (Computational Intelligence)

Machine Learning and Data Science for Solving Real-world Problems

In our work on applied machine learning (computational intelligence), we conduct practical research on machine learning and data science with a view to developing solutions to real-world problems and challenges in the fields of natural sciences and education. In life sciences and chemistry, discrete combinatorial structures, such as genome sequences, molecular structures, and intermolecular interactions, need to be reflected in machine learning. We are developing technology to address these need. In education, we are working on the development of an educational information platform and methodology to improve the effectiveness and efficiency of our own learning. Our goal is to pave the way for a new foundation for computational intelligence, by making concrete implementation through scientific discovery and understanding; through integration with general discrete structure processing using symbolic logic, knowledge representation, and algorithm design; and by comparison between human and machine learning.

[Akihiro Yamamoto, Ichigaku Takigawa, Brendan John Flanagan]

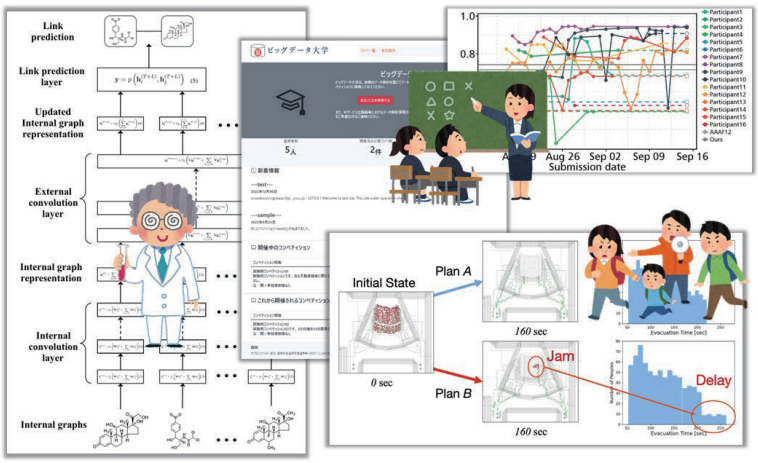


Applied Machine Learning (Collective Intelligence)

Pioneering Innovative Applications of Data Analytics

We focus on research and development in statistical machine learning and data mining techniques, and design data-driven solutions that address critical challenges in various domains, such as healthcare, biotechnology, pharmaceuticals, education, transportation, and marketing. By collaborating with industry leaders, governmental agencies, and other organizations, our goal is to break new ground in the applications of data analytics and generate impactful solutions for real-world problems.

[Hisashi Kashima , Koh Takeuchi]



Leveraging advanced analytics to address challenges across various domains.

Outline

Medical and Healthcare Data Science

The medical research outlined below is conducted mainly in Kyoto University Hospital.

Research Themes

■ **Epidemiological research utilizing clinical data including imaging and genetic data**
Clinical research consisting mainly of observational studies, in combination with multimodal imaging and genetic data, elucidating pathophysiology or predicting prognosis.

■ **Epidemiological research utilizing claims data, including the National Database of Health Insurance Claims and Specific Health Checkups of Japan (NDB)**
Epidemiological studies based on the secondary use of claims data, which plays a central role in the Data Health Plan featured in the Japan Revitalization Strategy

■ **Research on implementation and improvement of hospital information systems for improving hospital management**
Research aimed at improving hospital management by organizing and verifying implementation of issues in the renovation, improvement, and secondary use of hospital information systems involving new technologies such as IoT and AI

■ **Research on the development of a gaze analyzing visual function evaluation device**
Study on using a "gaze analyzing visual function evaluation device" featuring eye tracking and AI for analysis, to assess multiple visual functions, such as visual acuity and eye movements, with a focus on the visual field. A further goal is to develop more advanced eye tracking technologies suitable for screening of cognitive impairment.

[Hiroshi Tamura]

Computational Intelligence Systems (Adjunct Unit)

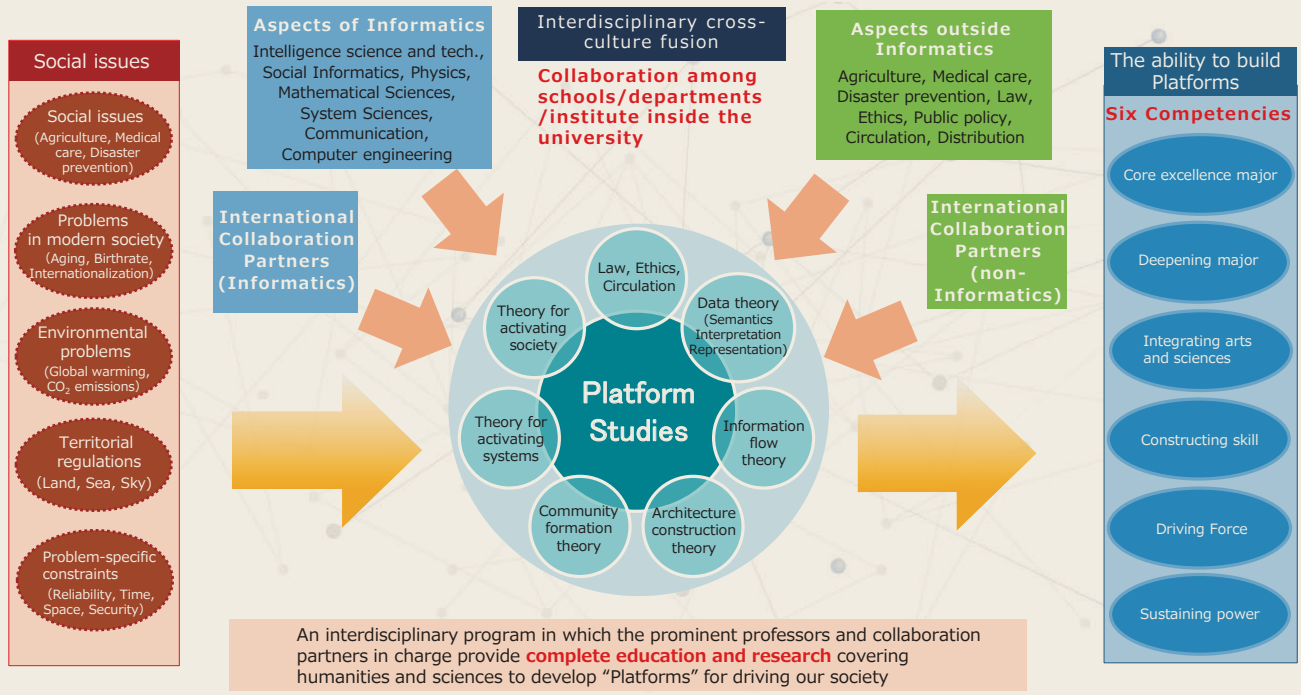
Toward Knowledge Creation from Diverse Data

With advances in deep learning, machine learning methods have achieved a high level of performance in image and language processing. However, when a large quantity of good training data is not available, low performance becomes a problem. To enable the effective use of machine learning in a broader range of fields, we are working on machine learning methods that can achieve high performance even under undesirable conditions, e.g., when there are only a small amount of data available or when high-quality data cannot be obtained. More specifically, we are working on meta-learning, i.e., the process of learning how to learn, and on machine learning that takes advantage of inductive bias.

[NTT Communication Science Laboratories: Naonori Ueda, Tomoharu Iwata]

Kyoto University School of Platforms (KUSP)

The Kyoto University School of Platforms (KUSP) is a five-year doctoral program designed to cultivate students capable of creating a "platform that activates society." By making full use of interdisciplinary expertise that encompasses information and telecommunications network technology, big data analysis/utilization technology, and the humanities, the program aims to reduce social risks involved in various fields such as agriculture, medical science, and disaster management. KUSP was selected as a FY2020 WISE Program (Doctoral Program for World-leading Innovative & Smart Education) by the Ministry of Education, Culture, Sports, Science and Technology (MEXT).



Participating Organizations

<<Kyoto University>>
<<Graduate School of Informatics>> Department of Informatics
<<Graduate School of Agriculture>> Agronomy and Horticultural Science, Forest and Biomaterials Science, Applied Biosciences, Environmental Science and Technology, Natural Resource Economics

Collaborating Organizations

Kyoto University: Graduate School of Informatics / Graduate School of Agriculture / Graduate School of Medicine / School of Government / Disaster Prevention Research Institute
Domestic partner institutions: National Institute of Information and Communications Technology / RIKEN / Japan Agency for Marine-Earth Science and Technology / National Agriculture and Food Research Organization /The Institute of Statistical Mathematics / Meteorological Engineering Center / Agriculture and Rural Development Information Center / The Research Institute for Humanity and Nature / Institute for Health Economics and Policy /
Advanced Telecommunications Research Institute International / KDDI Research,Inc / NTT Communication Science Laboratories / Nippon Telegraph and Telephone West Corporation / Yahoo! JAPAN Research / Mitsubishi Electric Corporation Information Technology R&D Center /
Sony Group R&D Center / NEC System Platform Laboratories /
Toyota Motor Corporation / Anritsu Corporation / Kadokawa ASCII Research Laboratories, Inc. /Ruby Association / Mitsubishi UFJ Research & Consulting Co., Ltd. / National Fisheries University / Jichi Medical University
Overseas partner institutions: University of Chicago / University of Illinois / University of Florida / Vienna University of Technology / University of Potsdam / Technical University of Berlin / Technical University of Munich / Delft University of Technology / Sorbonne University / Aalborg University / Huazhong Agricultural University / National Chung Hsing University / National Taiwan University / The French National Center for Scientific Research / Institute for Infocomm Research, Agency for Science, Technology and Research (A*STAR)

Platform Studies for Activating Society

Currently, efforts are fast underway to develop and utilize "platforms" that use telecommunications technology to collect information that is non-uniformly spread throughout our society. This information is digitally stored in the form of big data, which is then categorized, analyzed, and shared so that any outcome of the process may be fed back to society. The present platforms need a considerable amount of electric power and computational capability to collect and process big data. However, we can reduce the power consumption and costs if we consider the processes involved in decentralization, safety, and speed in the data generation and collection process. This requires exceptional informatics knowledge, which has as its focal point information and communication technologies. Meanwhile, deep learning and machine learning have become standard techniques and are often used in black boxes. Yet, it is possible to improve the output while reducing costs by correctly understanding and interpreting the data's meaning in each specific field and optimizing it. To achieve this, informatics must be combined with knowledge of different disciplines such as agriculture, medical science, disaster management, and other scientific studies.

The markets for cloud computing and communication networks are swiftly forming, but the reality is that Japan is failing to make its presence felt sufficiently in the process. One of the reasons for this is that only engineers are involved in platform development, which results in a lack of international perspectives in the standardization process and

business undertakings. For Japan to increase its presence in this all-important field, in addition to knowledge on informatics and non-informatics science studies, we need to amalgamate the knowledge of laws, ethics, public policies, data distribution, and other humanities studies that are required to implement new collective decision-making mechanisms, such as Japan's unique outlook on social ethics and fairness. With this combination of studies thus achieved, it must be applied to platforms and deployed globally. In this doctoral program, we call this interdisciplinary academic field "platform studies," which is essential in building platforms, and we propose to develop the required skills for this new academic discipline.

The Six Competencies Required of Platform Builders

To successfully complete this doctoral program on platform studies, one must acquire the following six competencies: ① **Outstanding core expertise** (advanced expert knowledge in the area of the primary major); ② **Expertise to deepen understanding in core fields** (expertise to explore core fields and the ability to foster sub-fields that complement them); ③ **The ability to build platforms on one's own initiative** (the ability to design/build platforms that offer solutions to social issues); ④ **The ability to get things done** (the ability to drive/manage large projects and expand their results globally); ⑤ **The ability to sustain momentum** (the ability to standardize results and develop social implementation in a sustainable manner); and ⑥ **The ability to integrate humanities and sciences** (knowledge on humanities required to build platforms, entrepreneurship, and the ability to create communities).

To ensure that students acquire "outstanding core expertise" in the areas of their primary major, the program provides students with lectures and seminars on such fields as informatics, agriculture, medical science, and disaster management, which are expected to help them deepen understanding of sub-fields while paying due regard to the curriculum of individual students' majors. Also provided are lectures and seminars on laws, ethics, data distribution, and other humanities studies needed to build platforms, which are designed to cultivate the ability to integrate humanities and sciences. Based on these inputs and research outcomes, students are expected to develop the skills to build platforms on their own initiatives, to promote/manage projects and implement and expand their results globally, and to standardize and socially implement the results so that they can develop the results in a sustainable manner. To assist them in doing so, the program offers guidance from instructors in multiple fields, research grants, research internships, research outcome matching events, international symposia, and other opportunities. Students will also be given access to state-of-the-art communication environments and various types of big data. These opportunities will be provided through industry-university-government cooperation among 39 institutions both within and outside of Kyoto University, including the Graduate School of Informatics, Graduate School of Agriculture, Graduate School of Medicine, School of Governance, and Disaster Prevention Research Institute.

●Website :
https://www.platforms.ceppings.kyoto-u.ac.jp/
●E-mail :
platforms_contact@mail2.adm.kyoto-u.ac.jp

Kyoto University Collaborative Graduate Program in Design

To respond to the complex needs of our modern society, Kyoto University Collaborative Graduate Program in Design is Japan's first program featuring an integrated, five-year curriculum for "Design" which seeks solutions by calling on knowledge from a variety of academic disciplines. This program aims at cultivating students who deepen their expertise in their own disciplines while working together with specialists in other disciplines as well as with stakeholders to deal with society's variegated issues and create a new structure for the society of tomorrow.

Students enrolled in this program conduct their studies around the six core disciplines of informatics,mechanical engineering, architecture, management, and psychology, while also engaging in a variety of training and field work aimed at acquiring the ability to design society. In order to participate in the program, a student must first be admitted into one of the five course in the Graduate School of Informatics: Intelligence Science and Technology Course, Social Informatics Course, Applied Mathematics and Physics Course, Systems Science Course, and Communications and Computer Engineering Course, and then can be considered for selection as a Preparatory Course student and Regular student in this program. Upon completing the program, students of the Doctorate Program of Graduate School of Informatics will earn either a Doctorate degree (Ph.D.) or a Doctoral Degree in informatics. As for the latter degree,certificate of the completion of the Program for Leading Graduate Schools'Collaborative Graduate Program in Design' is specified in the diploma.

Participant Organizations

Graduate School of Education (Division of Educational Studies), Graduate School of Engineering (Department of Architecture and Architectural Engineering, Department of Mechanical Engineering and Science, Department of Micro Engineering, and Department of Aeronautics and Astronautics), Graduate School of Informatics (Intelligence Science and Technology Course, Social Informatics Course, Applied Mathematics and Physics Course, Systems Science Course, and Communications and Computer Engineering Course), and Graduate School of Management (Department of Business Administration, Department of Management Science)

Partner Organizations

NEC Corporation, Nippon Telegraph and Telephone Corporation (NTT), Nomura Research Institute, Panasonic Corporation, Mitsubishi Electric Corporation, Mori Building, and about 70 members in Design Innovation Consortium (OMRON Corporation, Sony Corporation, Takenaka Corporation, DMG Mori Corporation, DENTSU Inc., Toray Industries Inc., Nikken Sekkei, The Japan Research Institute, Nippon Telegraph and Telephone West Corporation (NTT WEST), HAKUHODO Inc., Yamaha Motor, Yokogawa Electric Corporation, etc.)

●Website : https://www.design.kyoto-u.ac.jp
●E-mail : contact@design.kyoto-u.ac.jp

International Program at Graduate School of Informatics

Three Courses of Graduate School of Informatics, namely, the Intelligence Science and Technology Course, Social Informatics Course, and Communications and Computer Engineering Course, have an International Program in their curriculum.

Students of the International Program are taught in English, receive guidance in English from their supervisors, and acquire Master's and Doctoral degrees exclusively in English.

These programs are open both international and domestic students.

The curriculum was established at Graduate School of Informatics after Kyoto University was designated as one of the hub universities for the Project for Establishing Core Universities for Internationalization (Global 30/G30), launched in 2009 by MEXT.

The purpose of the G30 Program was to cultivate top-notch individuals who would play an active role in the global arena by providing development opportunities through friendly competition with international students. Participating universities were called upon to provide quality education according to their respective functions and to create an environment that makes it easier for international students to study in Japan. To this end, the G30 program assisted Japan's leading universities generating a hub of internationalization, including development a system in which degree programs can be offered entirely in English, improving the environment to accept international students, and promoting of strategic international cooperation.

●International Programs website :
https://www.i.kyoto-u.ac.jp/introduction/g30.html
●Contact : jyoho-kyomu@mail2.adm.kyoto-u.ac.jp
(Student Affairs Division)

Curriculum Policy

Paying due respect to Kyoto University's principles, Kyoto University Graduate School of Informatics provides education that aims to develop students' leadership skills that are needed to solve the problems facing a knowledge-based society. As stated in the diploma policy, we train students as researchers to evolve "the study of information in a broad sense of the term," as defined by the graduate school, and to work as true professionals by acquiring high specialist knowledge in their academic disciplines and developing considerable expertise. To this end, our education consists of systematic and tiered academic programs designed to provide not only advanced knowledge and insight in each research field but also a comprehensive academic overview of informatics. These programs also help students acquire the qualities essential for a successful career in a global society, including high ethical standards and a keen sense of responsibility, along with communication skills.

To be more specific, this graduate school provides education designed not only to allow students to study the specialist field of their choice but also to equip them with a broad range of knowledge that transcends the boundaries of disciplines. If the systematic, tiered and high professional education that revolves around each course, coupled with research guidance given by academic advisers, is likened to the warp, the subjects taught across the courses and the research guidance that transcends the laboratory are the weft. The warp and weft here are aptly combined into an intricate educational system. Academic advisers also provide research guidance that helps students develop ethical standards, including research integrity, as well as a sense of responsibility. Furthermore, the graduate school offers some classes conducted in English, along with an academic program in which subjects are available only in English, in order to develop communication skills that students need to be successful in the international community. Each grade is determined by tallying exam scores and marks given for class participation, considering the objectives and characteristics of the subject. Grading is done strictly, according to the grading policy and the policy on examining theses. We also work with the university's other academic programs to provide educational support for students with a broad range of interests.

The master's program, which has a large number of lecture classes, is systematically structured to teach course subjects that are tiered in a way that enhances learning. In addition, it has the inter-departmental subjects "Perspectives in Informatics" as required electives, and some of which are offered in English. The program also provides guidance to help students with diverse backgrounds to improve their basic academic skills in informatics. Except for the required research guidance subjects, most of the program's subjects are electives. To help students choose which subjects to take, academic advisers provide them with a "course tree for learning" during discussion-based academic advising, and give advice based on each student's academic background and other learning-related factors, as well as what the students plan to do after completing the program. The doctoral program offers seminar subjects specific to each course, other than research guidance provided by academic advisers to each student. By receiving advice on research from advisers in different research fields, students acquire a broad academic overview.

The Guidebook and the electronic syllabuses for all students contain information about most subjects, together with grading criteria.

The master's program offers the curricula shown below so that academic advising is provided based on these curricula.

● **General Subjects Provided by the School (Compulsory Elective)**
The subjects "Perspectives in Informatics" are offered to help students acquire insights about the extent of informatics. Students are required to take at least one of these classes according to the requirements specified by their course.

● **Seminars and Exercises for Master's Thesis (Mandatory)**
Academic advisers conduct the subjects to provide research guidance that students need to write their Master's thesis. Some of the courses offer opportunities for students to receive guidance and advice from faculty members outside their labs.

● **Basic Subjects and Subjects Provided by the Course (Optional)**
Each of the courses offers the graduate subjects taught in lectures, workshops, practical training, seminars, and in various other forms. The objective of the basic subjects is to have students acquire basic skills and knowledge essential for learning in the courses where graduate students with diverse backgrounds enroll. The objective of the specialized subjects is to impart advanced specialist skills and knowledge in the relevant fields. Some of the courses may recommend that students take graduate subjects offered by other graduate schools at Kyoto University as electives.

When students choose which of the subjects to take, their academic advisers consider their undergraduate majors as well as their graduate research projects when giving counsel and advice to ensure that the students take classes suited to their aptitudes.

● **Auditing Subjects offered for undergraduate courses**
Since informatics spans a range of academic disciplines, some students, depending on their undergraduate majors, may need to acquire more basic knowledge and academic skills essential for the research they plan to conduct. If this is the case, students are encouraged to take basic undergraduate subjects the university offers in order to acquire the knowledge and skills they need. The credits earned from these subjects are processed as additional credits that do not count toward completing the degrees.

Requirements for Completion of the Master's Program
Students must earn at least 30 credits from the subjects listed below, according to their course's requirements. They are also required to receive the research guidance they need, and their Master's thesis must pass the evaluation and examination.

- **Seminars and exercises for Master's thesis (Mandatory) and Master's thesis (Mandatory)**
- **General subjects provided by the School (Compulsory elective)**
- **Basic Subjects and Subjects provided by the Course (Including Subjects Provided by Other Courses, Optional)**

Requirements for Completion of the Doctoral Program
Students must earn at least six credits from the subjects offered by Graduate School of Informatics. They are also required to receive the research guidance they need, and their doctoral thesis must pass the evaluation and examination.

- **Doctoral Thesis (Mandatory)**

Academic Programs

Graduate School of Informatics believes that its students should have an understanding of its philosophy and be committed to acquiring the academic knowledge and skills needed for "the study of information in the broad sense of the term" that the school presents. We seek to have a wide range of talented students who are eager to explore new realms of informatics for the future. Hence, we accept applicants from Japan or overseas with diverse backgrounds connected to "the study of information in the broad sense of the term." Whether the applicants are in sciences or humanities does not matter as long as they have basic academic skills at a certain level in the academic fields in which they seek to pursue their studies and research. We also keep the door wide open to applicants who already have a career but seek to enthusiastically learn informatics.

To elaborate further, our process of selecting from the talented and qualified applicants who are eager to learn basically consists of written and oral examinations. We accept a wide range of applicants, regardless of their backgrounds, who have a keen interest in any academic fields related to "the study of information in the broad sense of the term" that Graduate School of Informatics aims to pursue and who have basic academic skills in those fields, along with excellent communication skills. To select applicants for the doctoral program, we review submitted documents to identify applicants' determination and ability to commit to acquiring the most advanced knowledge about "the study of information in the broad sense of the term," which will then be built on their basic academic skills for their specialist fields. Then we accept those who are committed to the creation of academic studies and the research of technological developments in order to contribute to the future growth of informatics.

The table in the right column shows the number of students to be admitted.

Each course holds their graduate school entrance examinations sometime between mid-July and mid-August each year. Some of them do it in mid-December and accept applications again in mid-February. The courses also admit students who enroll in October.

Three of the courses, namely Intelligence Science and Technology, Social Informatics, and Communications and Computer Engineering Courses, accept applications to their international programs, which allow students to take all courses in English to complete the degree requirements.

Please see the application guideline for details.

Admission Quota

	Master's Program	Doctoral Program
Department of Informatics	240	60

The Number of Students to be Admitted by Course

	Master's Program	Doctoral Program
Intelligence Science and Technology Course	42	13
Social Informatics Course	50	14
Advanced Mathematical Sciences Course	20	6
Applied Mathematics and Physics Course	28	6
Systems Science Course	31	6
Communications and Computer Engineering Course	51	11
Data Science Course	18	4

University Fellowship in Informatics

If you wish to be a proficient researcher who leads research and development in informatics, you should enroll in a doctoral program. To lower the financial obstacles in obtaining a doctoral degree, the Kyoto University Science and Technology Innovation Fellowship has been established with support from the Ministry of Education, Culture,

Sports, Science and Technology (MEXT) under its University Fellowship Program for the Creation of Innovation in Science and Technology starting in 2021. Responsible for the fields of information science and AI, Graduate School of Informatics facilitates financial support for students in doctoral programs, who would lead research in their respective areas of specialty.

- **Number of fellowship recipients:** 25/grade
- **Stipends:** JPY1.8 million per year (in monthly installments of JPY150,000)
- **Research fund:** JPY300,000 per year (under management by supervisors)
- **Selection:** Applicants submit a statement of past research and research plan, as well as a letter of recommendation by their supervisors, based on which their past academic and research achievements and research perspectives after enrollment will be screened.

Recipients of the fellowship are requested to participate in programs, etc., organized by Kyoto University and Graduate School of Informatics, so that they can enhance their research prowess and build a career path in diverse academic and industrial fields after completing the program. Some of the programs include presentation of research at the Kyoto University ICT Innovation, participation in a research internship, or being a teaching assistant in data science.

●https://www.i.kyoto-u.ac.jp/fellowship/

Career path after graduation

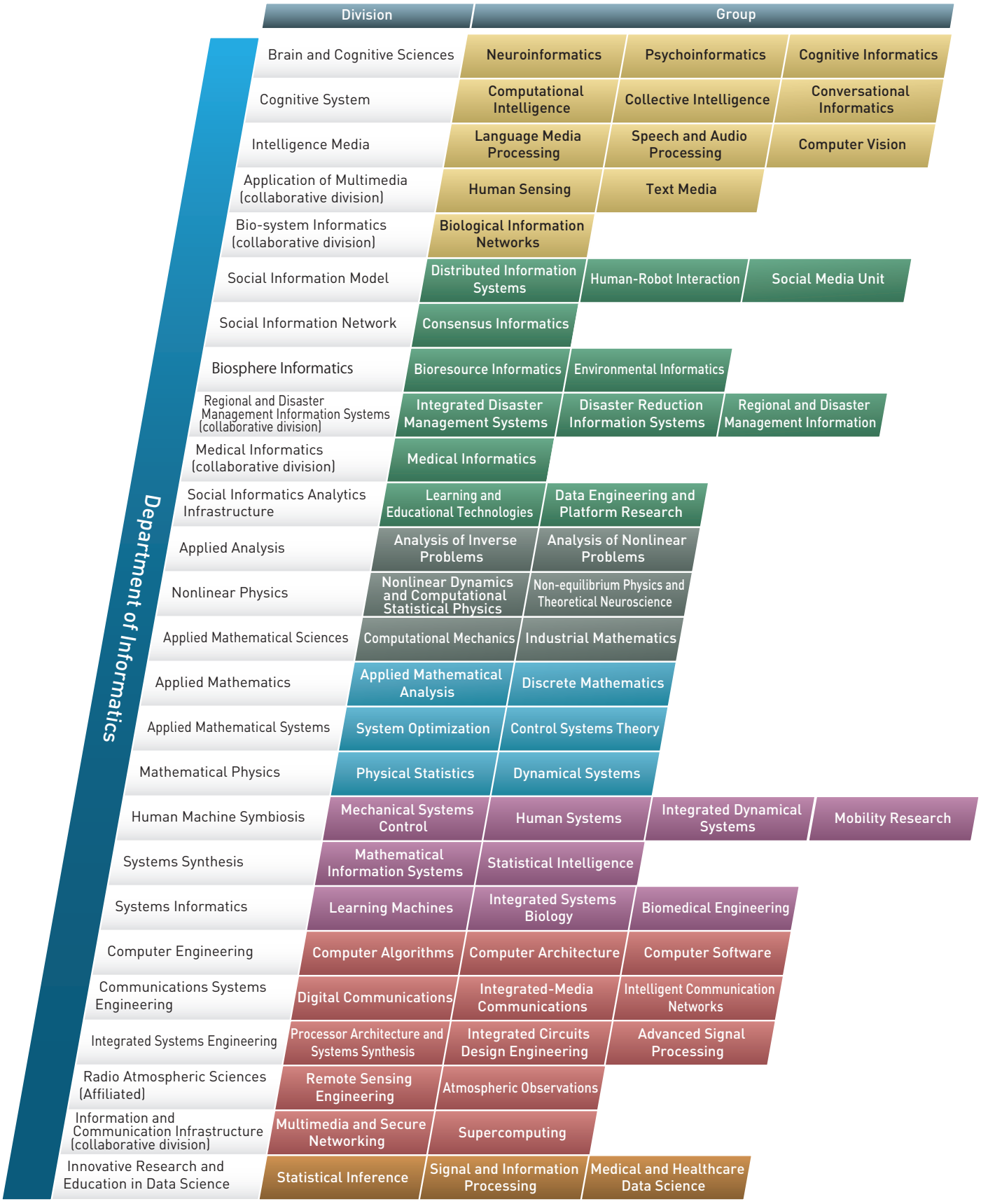
【Master's students】

Ministry of the Environment Government of Japan	SoftBank Corp.	TOYOTA SYSTEMS CORPORATION
Ministry of Land, Infrastructure, Transport and Tourism	DAIHATSU MOTOR CO., LTD.	BeNEXT Technologies
Sapporo Fire Bureau.	Panasonic Corporation Living Appliances and Solutions Company	Recruit Holdings Co., Ltd.
Kyoto University Hospital	Future Corporation	MUFG Bank, Ltd.
unerry, Inc.	FreeBit Co., Ltd.	Mitsubishi Research Institute, Inc.
atama plus Inc.	MCKINSEY & COMPANY, INC., JAPAN	Komatsu Ltd.
GMO GlobalSign K.K.	Miraxia Edge Technology Corporation	Kobe Steel, Ltd.
Huawei Technologies Co., Ltd.	morikatron Inc.	Hitachi, Ltd.
Indeed Japan co., Ltd.	Yahoo Japan Corporation.	Hitachi, Ltd. Central Research Laboratory
KDDI CORPORATION	Yamaha Motor Co., Ltd.	Honda R&D Co., Ltd.
LINE Corporation	CINC corp.	Nomura Research Institute, Ltd.
Mc Digital. Inc	JR East Information Systems Company	Hankyu Hanshin Holdings, Inc.
PwC Group	KADOKAWA CORPORATION	Mitsubishi UFJ Information Technology, Ltd.
TSMC Design Technology Japan, Inc.	MonotaRO Co., Ltd.	Mitsubishi UFJ Morgan Stanley Securities Co., Ltd.
Accenture Japan Ltd	NTT DOCOMO, INC.	Sumitomo Electric Industries, Ltd.
Amazon Japan G.K.	Infcurion, Inc.	MORI BUILDING CO., LTD.
IDEA Consultants, Inc.	Elysium Co. Ltd.	NIPPON TELEGRAPH AND TELEPHONE CORPORATION
Excite Japan Co., Ltd.	CAPCOM CO., LTD.	TOKIO MARINE & NICHIDO RISK CONSULTING CO., LTD.
Angel Group Co., Ltd.	Keyence Corporation	Tokyo Gas Co., Ltd.
KOEI TECMO GAMES CO., LTD.	KOEI TECMO HOLDINGS CO., LTD.	NS Solutions Corporation
Kiuchi Instruments Maintenance Corporation	CyberAgent, Inc.	IBM Japan, Ltd.
Google LLC	SEGA CORPORATION	NEC Corporation
GREE, Inc.	SenseTime Japan Ltd.	NIPPON TELEGRAPH AND TELEPHONE CORPORATION
Cybozu, Inc.	Sofix CO., LTD.	Nintendo Co., Ltd.
Sharp Corporation	DeNA Co., Ltd.	Honda Motor Co., Ltd.
Sony Group Corporation	DISCO Corporation	Nomura Asset Management Co., Ltd.
Sony Semiconductor Solutions Corporation	DataGrid Inc.	Nomura Securities Co., Ltd.
Sony Corporation	TechnoPro, Inc. TechnoPro Engineering Company	

【Doctoral students】

Seikei University	Nagoya University	OMRON Corporation
RIKEN	Yamato University	ROHM Co., Ltd.
National University Corporation, Kyoto University.	National Institute of Technology (KOSEN), Sasebo College	MonotaRO Co., Ltd.
University of Osaka	GMO Pepabo, Inc.	Nomura Securities Co., Ltd.

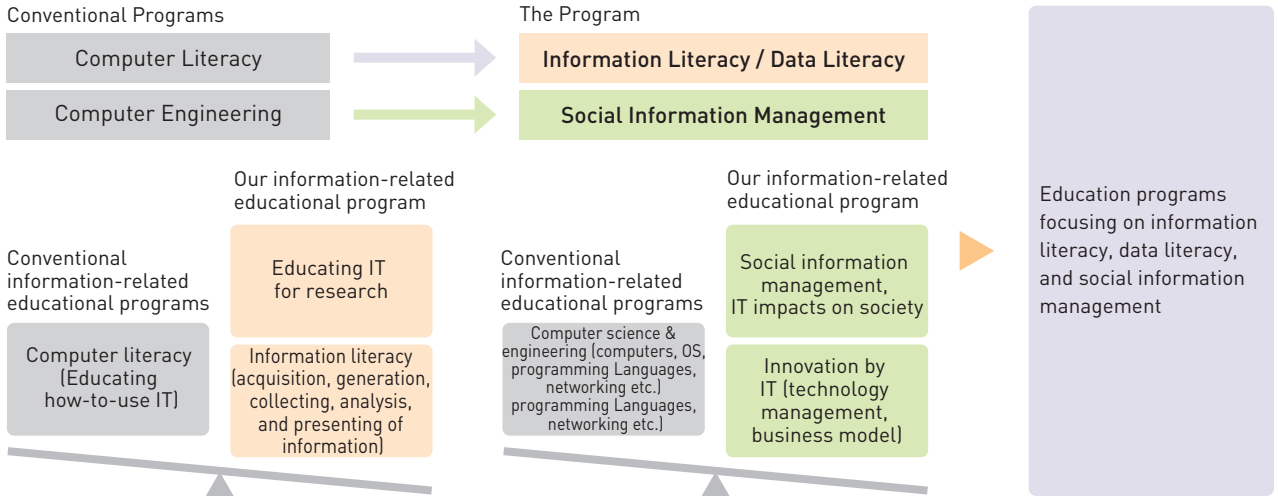
List of Departments, Divisions and Groups



Advanced Information-Education & Digital Education Infrastructure Unit
(Center for the Promotion of Interdisciplinary Education and Research(C-PiER))

The Advanced Information-Related Education & Digital Education Infrastructure Unit was established in Kyoto University C-PiER to implement the budget request project: Fostering Global Human Resources by Innovating Undergraduate/Graduate-level Information-related Education & Digitized Education of Graduate school of informatics, Kyoto University. It is our hope that students who will shape the future of our society will acquire essential skills to utilize information regardless of their areas of expertise so that they can enhance their information and communication skills as well as their global mindset.

Innovative Educational Programs



Digitized Education Environment

BYOD Classroom Learning
- Usage of tablets & note PCs in usual classrooms
- Active learning classrooms

Online Lectures
- Online Lectures

Faculties

Akihiro Yamamoto
Unit Leader / Professor
Graduate School of Informatcis

Nobuo Yamashita
Professor
Graduate School of Informatics

Keishi Tajima
Professor
Institute for Liberal Arts and Sciences

Yoshikazu Maegawa
Professor
Graduate School of Management

Hiroyuki Sato
Associate Professor
Graduate School of Informatics

Satoshi Shimada
Senior Lecturer
Graduate School of Management

Huang, Yinjou
Program-Specific Assistant Professor
Graduate School of Informatcis

Kanae kotigami
Program-Specific Assistant Professor
Graduate School of Informatcis

Courses

[Liberal Arts Courses]	・Basic Informatics (General) ・Informatics Fundamentals & Practice ・Information and Enterprise	・Introduction to Information & Intellectual Property ・Innovation and Information ・Information and Society

[Graduate Courses] Interdisciplinary Graduate Courses	・Information Analysis and Management ・Computational Science, Introductione ・Exercise on Computational Science B ・Service Modeling & Applying Strategy ・Innovation and Information	・Information Security	・Information Analysis and Management, Exercise ・Exercise on Computational Science A ・Information and Intellectual Property ・Computation Science for Big Data ・Artificial Intelligence, Advanced

Contact Yoshida Honmachi, Sakyo, Kyoto 606-8501 Research Building #12, Rooms 110, 112 E-mail : iedu@i.kyoto-u.ac.jp

The Kyoto University ICT Collaboration Promotion Network

The Kyoto University ICT Collaboration Promotion Network was jointly established by Graduate School of Informatics and the Academic Center for Computing and Media Studies at Kyoto University in February 2008.

This network serves as a foundation for industry-government-academia, academia-academia, and community-academia collaborations between faculty, researchers, and (graduate) students of Graduate School of Informatics and Academic Center for Computing and Media Studies and companies, NPOs, local governments, and other entities outside the university.

Kyoto University ICT Innovation

At this annual event, faculty, researchers, and graduate of Graduate School of Informatics and Academic Center for Computing and Media Studies offer outlines of their research and development work relating to information and communication technologies (ICT), in the form of posters, demonstrations, and oral presentations. In addition to presentations on the latest technologies and products, the event includes the introduction of collaborative initiatives with industry, government, and academia.

The main purpose of the annual event is to promote industry-academia matching. The presentations of research focus on concrete results, particularly software and products. The event will also be organically linked to guidance for job seekers. This event will be organized in collaboration with Kyoto Prefecture, Kyoto City, and other local organizations, with the aim of making it more accessible to the general public.

ICT Innovation is open to everyone, but exhibitors from outside the university can participate only if they are members of the ICT Collaboration Promotion Network.

Coordination of Industry-Academia Collaboration

1. Industry → Academia

We collect technology development themes from companies participating in the Collaboration Promotion Network, taking a view directed five to 10 years into the future. Typically, we suggest that applicant companies describe two or three themes on a few PowerPoint slides. The secretariat then attempts to match our labs with companies that have expressed interest, thereby opening the way for joint research or contract research.

2. Academia → Industry

The university collects research findings that show promise for practical implementation and discloses them to companies participating in the "Collaboration Promotion Network."

The secretariat then conducts small seminars for matching with companies that have expressed interest, paving the way to a joint or contract research project.

A unique feature of this coordination is that the Collaboration Promotion Network Steering Committee systematically match all the labs of Graduate School of Informatics and the Academic Center for Computing and Media Studies with the relevant departments of the approximately 50 member companies of the network. This has already led to the launch of a completely new type of collaborative research project.

For more information, contact us at the email address on the right.

Kyoto University Original Co., Ltd.　mail : ictrenkei@kyodai-original.co.jp

Request for Donations to the Fund

Graduate School of Informatics Fund

Graduate School of Informatics was established on three key pillars: interfacing with humans and society, mathematical modeling, and information systems. The educational goal of the graduate school is to train researchers to develop the field of informatics and high-quality, skilled professionals, by fostering high-level research skills and rich academic learning, to help cultivate outstanding individuals with a broad vision and the potential to become leaders in solving a wide range of real-world problems.

Generating new ideas and innovations that will support our future society requires the ability to think theoretically and abstractly, the ability to clearly distinguish the essential from the inessential, and the ability to build and organize ideas. In all its education and training activities, the Kyoto University Graduate School of Informatics has always put a strong emphasis on the cultivation of these fundamental skills, on top of the acquisition of expert knowledge in specific fields. The purpose of Graduate School of Informatics Fund is to help us to enhance our efforts at cultivating human resources, both in terms of quality and quantity, and to support original research with the potential to create future innovations.

Use of the Fund

- **Supporting the study and research of graduate students**
  Providing scholarships, mainly for doctoral students
  Providing opportunities to send students to study at other universities, research institutes, etc. overseas or in Japan
- **Supporting young researchers**
  Providing opportunities to send young researchers to overseas universities or research institutions for medium to long periods
- **Supporting research**
  Supporting the work of researchers affiliated with Graduate School of Informatics

※Donations can also be made to a specific research project, or specific faculty member or researcher at the graduate school, or for a specific use. If you would like to offer a donation, please contact us at the email address below.

Benefits for donors

- Receiving PR information about Graduate School of Informatics
- Receiving information on academic events organized by Graduate School of Informatics
- Names of donors are included in PR materials of Graduate School of Informatics
- Priority when registering for lectures or other events organized by Graduate School of Informatics (when places are limited)
- Opportunity to join social gatherings with faculty members of Graduate School of Informatics (about once a year)

If you would prefer not to receive any of the above benefits, please let us know.

For inquiries about Graduate School of Informatics Fund: 075-753-5945 infofund@i.kyoto-u.ac.jp

Donation can be made here.

Kyoto University Fund WEB page

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