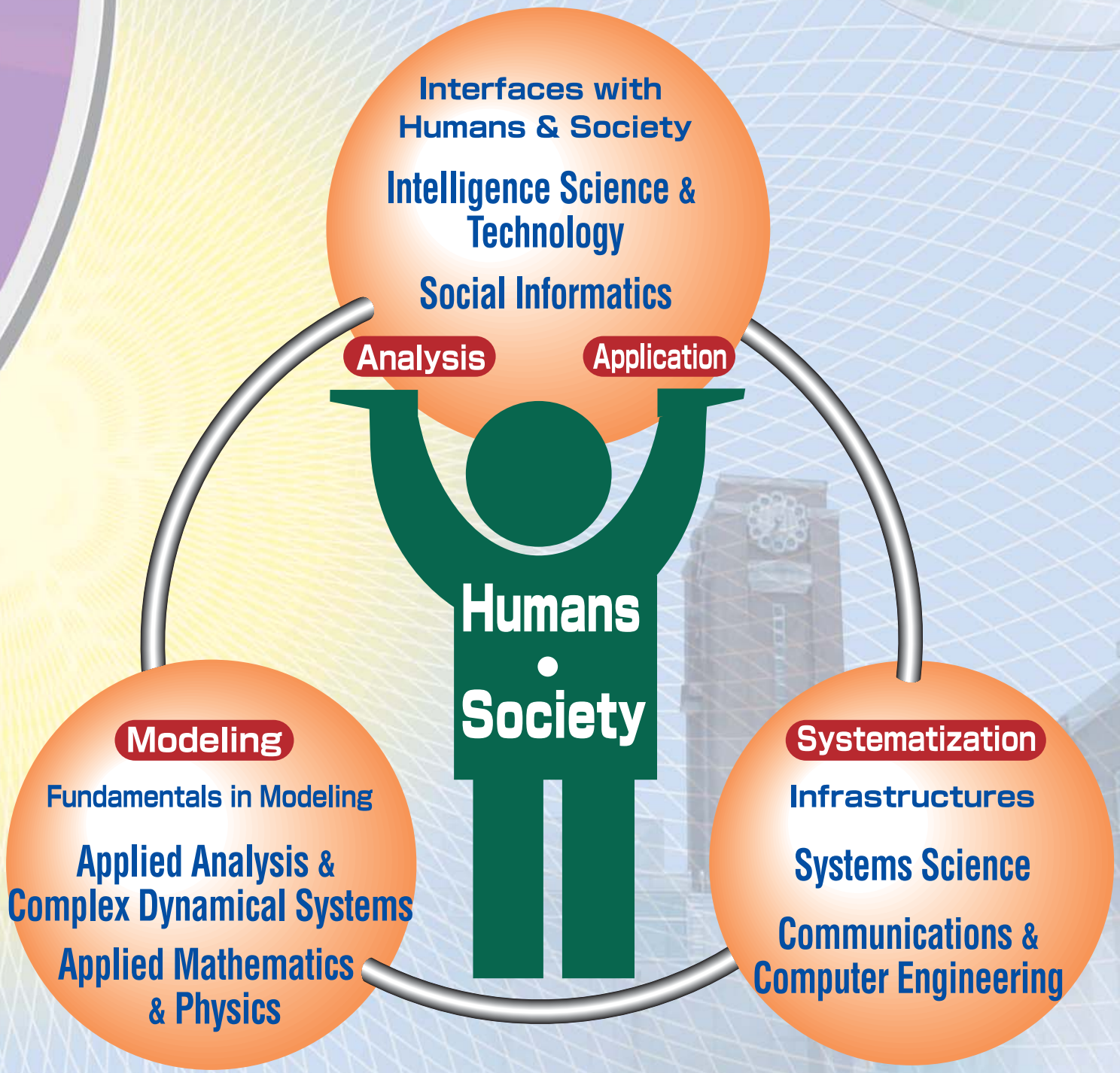
# Contents



(Published in April 2014)

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


Interfaces with
Humans & Society
Intelligence Science &
Technology
Social Informatics
Analysis
Application
Humans
•
Society
Modeling
Fundamentals in Modeling
Applied Analysis &
Complex Dynamical Systems
Applied Mathematics
& Physics
Systematization
Infrastructures
Systems Science
Communications &
Computer Engineering

# An Invitation to [Join ]the Graduate School of Informatics

Toru Sato
Dean, Graduate School of Informatics

## Introduction

It is said that computers began to find a place in ordinary people's lives around the time that the IBM PC was launched in 1981. For the majority of today's students, computers have always been a familiar presence in many aspects of daily life. Today, computers are indispensable tools in transport, finance, and so many other fundamental areas of our social infrastructure. As demonstrated by the once thriving domestic supercomputer industry, Japan has made significant contributions to rapid advances in hardware technology. However, in fields such as systems software and standard application software, development has proved to be more difficult. Windows 95, dubbed the biggest hit product of the 20th century, is a case in point. Similarly, the dramatic rise of the Internet since the late 1990s can hardly be attributed to Japanese technology; other countries have been the sources of new Internet business models such as Google and Facebook. That said, intelligent appliances, automobiles, robots, game consoles and other highly distinctive products that incorporate ICT continue to support Japan's economic ascendancy, even as developing countries threaten to challenge our country's pre-eminence in these areas.

Today's students are members of a generation that has grown up in an environment where computers and computer networking are deeply [embedded][entwined] in the social infrastructure. For this generation, the "Net" probably is just subconsciously "there", like electricity reticulation and water supply, which are only really appreciated when they cease to function. However, considering that even the mobile phone did not exist when these students' parents' generation was growing up, we should recognize that ICT is not a mature infrastructure but rather an emerging technology whose enormous impact on the coming age is hard to envision.

In this article, I seek to [reach out to][address] all young persons with an interest in computers and their potential. I explain the aims behind the foundation of the Graduate School of Informatics and, from a personal perspective, consider where our graduate school stands today and where it may be headed.

## Birth of the Graduate School of Informatics

In April 1998, information-related research fields that had previously been dispersed across five different faculties within Kyoto University (Engineering, Science, Agriculture, Letters and Integrated Human Studies) were reorganized and integrated to form the Graduate School of Informatics. This new school was designed to incorporate research on the processes of information synthesis, transmission, conversion, reception and storage, and the areas of computer hardware, software and communications technology which facilitate such processes, as well as mathematical, systems-scientific, simulation-based and social research on information-related issues which encompass the abovementioned themes. The disciplinary breadth and variety of the new school necessitated adopting the term "informatics" − the study of information − instead of applying one of the terms already used within Japanese universities, such as information engineering or information science. The school's enrollment capacity − initially 165 (now 189) in the master's program and 74 (now 60) in the doctoral program − is several times larger than was the case when students were being enrolled in the Department of Information Engineering in the Graduate School of Engineering. The important point is that the founders of our school sought to go beyond simply [lumping together][amalgamating] a substantial number of research fields on information-related issues and to pursue "advancement of pioneering and creative interdisciplinary research, and construction of the field of informatics in order to cultivate highly skilled individuals with broad intellectual

horizons." Guided by this aim, since its establishment the school has operated cooperative laboratories in collaboration with research institutes within Kyoto University, and has developed partnerships with a number of corporate research institutes, thereby extending the scope of educational activity within the school.

## Study at the Graduate School of Informatics

In April 2014, the Graduate School of Informatics embarks on its 17th year of operation. How much progress has been made toward realization of the school's founding aim of constructing the discipline of informatics? There is a vigorous program of research covering the areas of information synthesis, transmission, conversion, reception and storage. We have graduated from the stage at which new concepts emerge in quick succession and we are now well placed to explore research topics in greater depth. Research on computer hardware and software, the fundamental area of study and development in information engineering, is being carried forward by our school in cooperation with the Academic Center for Computing and Media Studies. Research projects concerning communications technology, applied mathematics and physics, systems science and simulation are largely carried out on an independent basis; however, as a result of shifting the focus of our academic staff recruitment policies away from the traditional fields and more toward informatics, a loosely [structured] [formed] strategic research vector is beginning to take shape. The quality of research output in the above areas has increased steadily and many of our projects could be considered to be truly pioneering and unique.

In contrast, we still have a long way to go in our task of establishing new interdisciplinary fields in the domain of informatics. We await the emergence of a new set of core scientific principles. One candidate for the kinds of concepts we are currently pursuing is "design." While mathematics concentrates purely on the logical aspects of the human brain, and engineering is aimed at controlling the physical world, informatics deals with both "cyber" and "real" worlds. This difference in nature of the respective fields may explain why the process of designing an ICT device affords much greater freedom than that for designing an automobile. In order to resolve some of the complex issues faced by contemporary society, such as global warming, disaster prevention, food safety, and an aging society, we need to start by seriously thinking about what is involved in designing something. This may show us how to handle a flood of information and how to make positive use of it for the benefit of our society.

Ten years is too short a time for the reorganization and integration that took place when our school was founded to have evolved into regular interaction and amalgamation; we may have to wait a little longer for the emergence of individuals whose abilities were cultivated in our school and who are capable of leading this process. We invite young, talented people to join us, bringing with them minds that are open and not likely to be [contained][restricted][bound] by the school's current framework.

## Education at the Graduate School of Informatics

The curriculum of the Graduate School of Informatics is designed to both enhance students' expertise and broaden their horizons. Offered across the six Departments of Intelligence Science and Technology, Social Informatics, Applied Analysis and Complex Dynamical Systems, Applied Mathematics and Physics, Systems Science, and Communications and Computer Engineering, the curriculum uses the broad themes expressed by those departmental names to connect a diverse collection of research areas. The prime focus of our efforts is "on-the-research" supervision subjects in which master's and doctoral students prepare their dissertations. Students pursue "independent and interactive learning" with the aim of becoming fully fledged researchers and highly skilled technical professionals. Most students will have already made conference presentations or had papers published in domestic and international journals by the time they submit their dissertations; a number of them will also have received "best paper" prizes and incentive awards.

In the 2012 academic year, with support from the Ministry of Education, Culture, Sports, Science and Technology, the Leading Graduate Schools Doctoral Program was initiated. Our school has been participating in two programs: the Inter-Graduate School Program for Sustainable Development (from the 2012 academic year),

and the Collaborative Graduate Program in Design (from the 2013 academic year). These programs connect the master's and doctoral programs across disciplines and, through mobilization of first-class faculty staff members and students from within and outside of Japan and involvement by industry, academia and government, are aimed at developing talented students into future leaders who can become globally active [and cross][across] the boundaries between industry, academia and government, applying broad perspectives and creativity. Our school is especially committed to taking the lead in the latter area through our "Design School" positioning because, as stated above, design [capabilities][principles] are expected to constitute a core academic discipline in next-generation society. By fostering the study of "design" as a common language between different fields, we develop experts who are capable of changing our society. We call such experts "+ shaped people," meaning outstanding experts who can collaborate with others beyond the boundaries of [individual ]expertise. Cultivation of such "+ shaped" human resources is the goal of this program. In pursuit of this objective, we [import][bring in] real-world issues, through collaborative arrangements with cutting-edge companies, to facilitate field-based learning (FBL) and problem-based learning (PBL). We also encourage overseas internships whereby students work at companies in various countries through collaboration with world-leading universities.

In the 2010 academic year, we introduced three International Courses in which participants can complete coursework in an English language-only medium. We have four non-Japanese faculty members, and both foreign and Japanese students study informatics together in this program.

The founding [mission][aim] of the Graduate School of Informatics is to cultivate highly skilled individuals with broad intellectual horizons. We seek particularly to foster the development of young persons who can apply fundamental principles to the conception of new research approaches for the next-generation field of informatics, advocate those approaches, and use their own initiative to break new ground. We are still only midway along the road toward establishing informatics as a new interdisciplinary field of academic endeavor; however, given the steady advances being made in the area of human resources development, the way ahead is finally becoming clear.

## Conclusion

The Kyoto University Graduate School of Informatics was founded not as a response to the short-term cycle of contemporary social needs but rather as a force to help propel Japan once again to the forefront as a nation founded on scientific and technological prowess. Lying beyond this goal are the challenges of sustainable human development and coexistence. Energy and environmental issues, medical care and cultural matters also await further development of informatics. No matter how favorable the conditions or how lofty the ideals, it is not possible to create a global-standard hub of academic activity overnight. A new generation of individuals to carry our mission forward can only be cultivated if we persevere in our dual tasks of offering education attuned to individual student development and engaging in research that gives concrete form to novel ideas. This is precisely why the aim of the Graduate School of Informatics is to cultivate highly skilled individuals with broad intellectual horizons.

As I stated at the outset, half-baked modifications and improvements are of little use in the field of information and communications technology. A single, intrinsically superior format supported by a novel concept can survive and become the global standard in its field. In this respect, the domain of information and communications technology is vastly different from areas in which Japan's traditional strengths lie, such as the manufacture of intelligent appliances and automobiles. The power to think from basic principles can only grow out of education that fosters an appreciation of fundamentals. I have high hopes for the young talent who will join us here at the Graduate School of Informatics.

# Departments

## Department of Intelligence Science and Technology

| Division | Group | Research and Education Topics |
|---|---|---|
| Biological and Cognitive Processing | Biological Information | Operating Principles of the Nervous System and the Brain and Basic Principles of Information Processing |
| | Cognitive Science | Information Processing Mechanisms in Human Cognitive Process |
| | Hearing and Speech Processing (Adjunct Unit) | Speech Observation and Signal Processing Techniques |
| Intelligence Information Processing | Foundation of Software Science | Machine Learning and Data Mining |
| | Intelligence Information Processing Principles | Information Modeling for Intelligent Information Processing Mechanism |
| | Applied Intelligence Information Processing | Understanding and Designing Interaction, Human Computer Interaction Using Visual Information |
| Intelligence Media | Language Media Processing | Natural Language Processing, Knowledge Engineering |
| | Speech Media Processing | Recognition, Understanding, Conversion and Generation Methods for Speech, Music and Environmental Sounds |
| | Visual Information Processing | Image Recognition and Understanding, Human Communication, Smart Energy Management |
| Computational Biology | | Human Attention and Executive Function, and Cognitive Interface |
| Application of Multimedia (Affiliated) | Video Media | Human-Computer Interaction through Video Images |
| | Network Media | Techniques to Realize Multimedia Information Network |
| | Media Archiving Research | Advanced Digital Archiving via Speech and Language Processing |
| Bio-system Informatics (Affiliated) | Biological Information Networks | Bioinformatics, Computational Systems Biology |

## Department of Social Informatics

| Division | Group | Research and Education Topics |
|---|---|---|
| Social Information Model | Distributed Information Systems | Technical Issues and Applications Used in the Formation of Distributed Information Systems |
| | Digital Library | Digital Contents and Information Access Architecture as Social Information Infrastructures |
| | Information Society (Adjunct Unit) | Management of Intellectual Property and Associated Information |
| Social Information Network | Global Information Network | The Formation of Social Systems Based on Information Networks |
| | Information Security (Adjunct Unit) | Encryption and Authentication System |
| | Market and Organizational Information Systems (Adjunct Unit) | Information Society, Information Economy, Information Policies and Corporate Information Strategies |
| Biosphere Informatics | Bioresource Informatics | The Processing and Analysis of Biosphere Resource Data |
| | Environmental Informatics | Investigating Interactions between Human Society and the Biosphere Environment |
| Regional and Disaster Management Information Systems (Affiliated) | Integrated Disaster Management Systems | Disaster Information Systems and Building Disaster Prevention Systems |
| | Emergency Management for Disaster Reduction Systems | Social Scientific Research for Disaster Damage Reduction |
| | Crisis Information Management System | Practical Disaster Management for Business Continuity |
| Medical Informatics (Affiliated) | | Interaction between Information Systems and Medical and Social Organizations |
| Information Fluency Education (Affiliated) | | Training People to Use Information Technology in Various Areas |
| EHR Research Unit | | Distributed Medical Information Infrastructures for Electronic Health Record and Clinical Research |

### Department of Applied Analysis and Complex Dynamical Systems

| Division | Group | Research and Education Topics |
|---|---|---|
| Applied Analysis | Applied Analysis | Analysis of Inverse and Ill-posed Problems, Non-linear Problems, Analysis on Fractals, Numerical Analysis, Partial Differential Equation, Harmonic Analysis, Scientific Computation |
| Complex Dynamics | Nonlinear Dynamics | Fluid Dynamics, Computational Physics, and Nonlinear Oscillators |
| | Nonequilibrium Dynamics | Theoretical Neuroscience, and Network Science, Nonequilibrium or Nonlinear Physics, and Network Dynamical Systems |
| Applied Mathematical Sciences | Computational Mechanics | Computational Mechanics and Monte Carlo Simulations |
| | Intelligent and Control Systems | System Control, Digital Signal Processing, Modelling, and System Design Theory |

### Department of Applied Mathematics and Physics

| Division | Group | Research and Education Topics |
|---|---|---|
| Applied Mathematics | Applied Mathematical Analysis | Applied Integrable Systems and Numerical Algorithms |
| | Discrete Mathematics | Theory and Application of Discrete Optimization, Graph Theory, and Discrete Algorithms |
| Applied Mathematical Systems | System Optimization | Optimization Theory & Algorithms and Operations Research |
| | Control Systems Theory | Systems Control Theory, System Identification and Large-scale and Stochastic Dynamical Systems |
| | Applied Mathematical Modeling (Adjunct Unit) | Applied Mathematical Modeling and Social Information Systems Modeling |
| Mathematical Physics | Physical Statistics | Physical Statistics, Basic Theory of Nonlinear and Complex Systems, and Stochastic Process Fundamentals and Applications |
| | Theory and Applications of Dynamical Systems | Dynamical Systems, Ordinary and Partial Differential Equations, and Mathematical Physics |
| Mathematical Finance (Affiliated) | | The Science of the Functional Efficiency of Finance |

### Department of Systems Science

| Division | Group | Research and Education Topics |
|---|---|---|
| Human Machine Symbiosis | Mechanical Systems Control | Advanced Control Theories and Their Application to Mechanical Systems |
| | Human Systems | Human-Centered System Design, Modeling, Virtual Sensing, and Control |
| | Symbiotic Systems | Nonlinear Systems Theory, Optimal Control, Real-Time Optimization, Human-Machine Systems |
| System Synthesis | Adaptive Systems Theory | Adaptive, Learning, and Inference Theories and Their Application |
| | Mathematical System Theory | Mathematical Systems, Signal Processing, and Wireless Communications |
| | Computational Intelligence Systems (Adjunct Unit) | Data Mining and Pattern Recognition Based on Statistical Machine Learning |
| Systems Informatics | Information Systems | Synthesis, and Analysis and Evaluation Theories about Information Systems and Their Application |
| | Integrated Systems Biology | Modeling of Intelligence (Brain) and Life, and Its Application |
| | Biomedical Engineering | Information Systems for the Medical Field |
| | Computational Neuroscience (Adjunct Unit) | Computational Neuroscience, Brain Network Interface |
| | | Neural Circuit Information Processing, Neural Information Code |
| | | Basal Ganglia, Neuromodulators, Evolutionary Robotics |
| Applied Informatics (Affiliated) | | Supercomputers and High-Performance Parallel Processing |

## Department of Communications and Computer Engineering

| Division | Group | Research and Education Topics |
|---|---|---|
| Computer Engineering | Logic Circuits, Algorithms, and Complexity Theory | Logic Circuits, Algorithms, and Complexity Theory |
| | Computer Architecture | Parallel Computing Mechanisms, Arithmetic Operation Circuits, and Hardware Algorithms |
| | Computer Software | Programming Language Systems, Symbolic Processing, and Parallel Processing |
| Communications Systems Engineering | Digital Communications | Highly Reliable and Secure Broadband Digital Communications Systems |
| | Integrated-Media Communications | Integrated Transmission System and Applications |
| | Intelligent Communication Networks | Design and Performance Analysis of Highly Efficient Information Networks |
| Integrated Systems Engineering | Processor Architecture and Systems Synthesis | Large-scale, High-performance Information Circuit Architecture, and Design Technology |
| | Integrated Circuits Design Engineering | Design Technology of High Performance Large-scale Integrated Circuits |
| | Advanced Signal Processing | High-speed and High-precision Digital Signal Processing Methods |
| Radio Atmospheric Sciences(Affiliated) | Remote Sensing Engineering | Atmospheric Measurement and Geophysical Environmental Information by Radio Waves, Light, and Acoustic Waves Using Electronic Engineering |
| | Atmospheric Observations | |
| Global 30 | Geometric Computation | Geometric Computation, Discrete Optimization, and Quantum Information |

# Department of Intelligence Science and Technology

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

In an advanced information-oriented society, we require information processing with flexible, human-like information capabilities.

Information processing in human and animal organic systems has developed by means of structural and functional adaptation to the environment through a long process of evolution; there is no other high-level processing capacity quite like it.

Intelligence Science and Technology is a multidisciplinary field that aims to clarify the mechanisms of biological—particularly, human—information processing for the development of higher-level information processing.

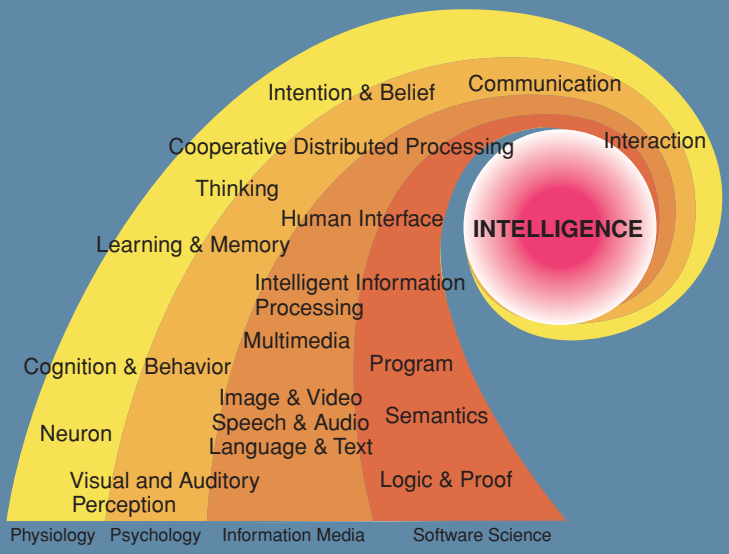
# *Welcome to the World of Intelligence Science and Technology*

MATSUYAMA Takashi, Department of Intelligence Science and Technology

Intelligence science and technology is a research field concerned with information processing performed by living organisms, particularly humans. The keyword, "intelligence," tends to be misconceived as referring to "artificial intelligence," but we consider intelligence science and technology from a far wider perspective. Education and research at the department cover multiple disciplines ranging from the study of media – such as images, sounds and languages, life, and cognition as the origins for intelligent information processing mechanisms, to more abstract information processing mechanisms, such as software and computer networks. The department is characterized by its pursuits for the essence of intelligence in these fields. Although the research fields cover a wide area, the faculty members and students in the department have a strong sense of unity, sharing the same goal of unraveling "intelligence." They are moving towards this goal by mutually imparting and receiving "knowledge" generated from their research through discussions. Both of the entrance examination and curriculum for our department are prepared to allow not only graduates from computer science and media informatics, but also students who have studied various fields would like to join us. We invite you all to come and dive into the whirlpool of knowledge and participate in our lively research activities.

# Department of Intelligence Science and Technology

## *Construction and Elucidation of Intelligence: Realization of Flexible, Human-like Information Processing*



# Divisions and Groups

| Division | Group | Research and Education Topics | Professor |
|---|---|---|---|
| Biological and Cognitive Processing | Biological Information | Operating Principles of the Nervous System and the Brain and Basic Principles of Information Processing | |
| | Cognitive Science | Information Processing Mechanisms in Human Cognitive Process | INUI Toshio |
| | Hearing and Speech Processing (Adjunct Unit) | Speech Observation and Signal Processing Techniques | MASAKI Shinobu |
| Intelligence Information Processing | Foundation of Software Science | Machine Learning and Data Mining | KASHIMA Hisashi |
| | Intelligence Information Processing Principles | Information Modeling for Intelligent Information Processing Mechanism | YAMAMOTO Akihiro |
| | Applied Intelligence Information Processing | Understanding and Designing Interaction, Human Computer Interaction Using Visual Information | NISHIDA Toyoaki |
| Intelligence Media | Language Media Processing | Natural Language Processing, Knowledge Engineering | KUROHASHI Sadao |
| | Speech Media Processing | Recognition, Understanding, Conversion and Generation Methods for Speech, Music and Environmental Sounds | |
| | Visual Information Processing | Image Recognition and Understanding, Human Communication, Smart Energy Management | MATSUYAMA Takashi |
| Computational Biology | | Human Attention and Executive Function, and Cognitive Interface | KUMADA Taketsune |
| Application of Multimedia (Affiliated) | Video Media | Human-Computer Interaction through Video Images | MINOH Michihiko |
| | Network Media | Techniques to Realize Multimedia Information Network | OKABE Yasuo |
| | Media Archiving Research | Advanced Digital Archiving via Speech and Language Processing | KAWAHARA Tatsuya |
| Bio-system Informatics(Affiliated) | Biological Information Networks | Bioinformatics, Computational Systems Biology | AKUTSU Tatsuya |

# Graduate Curriculum

**Courses for the Master's Program**

Introduction to Bioscience
Introduction to Information Science
Seminar on Biological Information Processing
Foundation of Software Science
Artificial Intelligence (Advanced)
Multimedia Communication
Language Information Processing (Advanced)
Visual Interaction
Introduction to Cognitive Science
Introduction to Bioinformatics
Seminar on Cognitive Science
Pattern Recognition (Advanced)
Foundations of Intelligent Systems
Speech Information Processing (Advanced)
Computer Vision
Advanced Research in Intelligence Science and Technology
Advanced Study in Intelligence Science and Technology I
Advanced Study in Intelligence Science and Technology II

**Courses for the Doctoral Program**

Advanced Seminar on Biological and Cognitive Processing
Advanced Seminar on Intelligence Information Processing
Advanced Seminar on Intelligence Media
Advanced Seminar on Gene Informatics
Advanced Seminar on Application of Multimedia
Advanced Seminar on Intelligence Science and Technology

# Teaching Staff

**Professors**

INUI Toshio; MASAKI Shinobu (ATR, Adjunct); KASHIMA Hisashi; YAMAMOTO Akihiro; NISHIDA Toyoaki; KUROHASHI Sadao; MATSUYAMA Takashi; KUMADA Takatsune; MINOH Michihiko (M); OKABE Yasuo (M); KAWAHARA Tatsuya (M); AKUTSU Tatsuya (Institute for Chemical Research)

**Associate Professors**

ISHII Carlos Toshinori (ATR, Adjunct); CUTURI, Marco; NAKAZAWA Atsushi; KAWAHARA Daisuke; LIANG Xuefeng; MUKUNOKI Masayuki (M); MIYAZAKI Shuichi (M); MORI Shinsuke (M)

**Senior Lecturers**

HOSOKAWA Hiroshi; MIZUHARA Hiroaki; YOSHII Kazuyoshi; SHIBATA Tomohide; KAWASHIMA Hiroaki; NOBUHARA Shohei

**Assistant Professors**

MAEGAWA Shingo; SASAOKA Takafumi; NAKAZAWA Koji; YOSHINAKA Ryo; OHMOTO Yoshimasa; ITOYAMA Katsutoshi; NISHIDE Shun; TUNG, Tony (M); ICHINOSE Natsuhiro; FUNATOMI Takuya (M); AKITA Yuya (M); HAYASHIDA Morihiro (Institute for Chemical Research); TAMURA Takeyuki (Institute for Chemical Research)

(M) : Academic Center for Computing and Media Studies

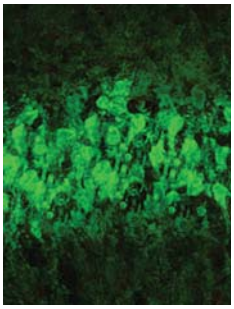
# Biological and Cognitive Processing

We aim to investigate both the cognitive and the physiological mechanisms of advanced biological, especially human, information processing and to explore possible applications of such mechanisms. For this purpose, we plan to analyze the information processing mechanisms of the nervous system at the molecular, biochemical and physiological levels; to elucidate the underlying principles; and to develop new artificial information processing systems. Moreover, we will analyze the processes of human sensation, perception, learning, memory, thought and inference from both a cognitive perspective and a computational neuroscience perspective in order to examine the mechanisms of these types of information processing.

## Biological Information

—The Basis of Biological Information—

Brain is constructed from neural cells in self-organized fashion using genome DNA information. Our educational and research goals are to elucidate the molecular basis of information processing system in brain by using biological experiments and mathematical modeling. Specifically, we focus on four research areas: non-verval communication; sensory information processing; autonomous regulation; and morphogenesis.
(Senior Lecturer: HOSOKAWA Hiroshi, Assistant Professor: MAEGAWA Shingo)

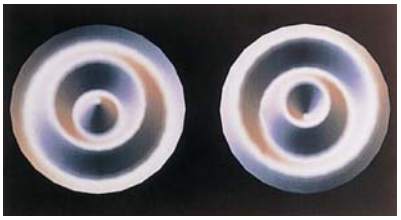


Neuronal cells

## Cognitive Science

—Towards a systematic understanding of the human brain—

In order to obtain a systematic understanding of the human brain, we will conduct both experimental and theoretical research and instruction on how higher human cognitive functions are carried out. Specifically, we will undertake studies involving both psychological experiments and neural network simulations to determine how various higher-level functions, such as visual pattern recognition, the integration of sensory information from various modalities, verbal and nonverbal communication, and motor control are carried out in the brain. We will also measure human brain activity using brain-imaging techniques.
(Professor: INUI Toshio, Senior Lecturer: MIZUHARA Hiroaki, Assistant Professor: SASAOKA Takafumi)



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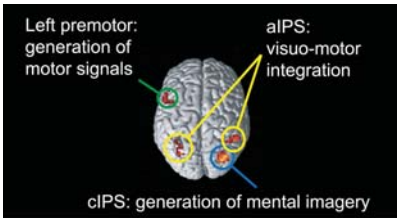



Cortical network for mental image transformation

## Hearing and Speech Processing Adjunct Unit

—Exploring speech production and reception mechanisms—

[in collaboration with the Advanced Telecommunications Research Institute International (ATR) ]

Speech is one of the most fundamental and important channels of communication. We aim to clarify the mechanisms of speech production and hearing processing using the latest observation and signal processing techniques. For speech production mechanism, we will create a speech production model based on MRI and the other visualization techniques. We will also approach hearing mechanism through functional MRI technique as well as experimentation and computer simulations.
[Professor: MASAKI Shinobu (ATR), Associate Professor: ISHII Carlos Toshinori (ATR) ]

# Intelligence Information Processing

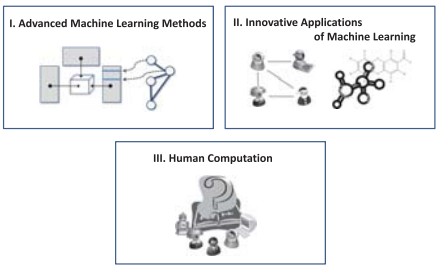
Our goal is to develop flexible and intelligent information processing. We will identify the basic components and structures of information, as well as study extraction, recognition, understanding, and representation of information. We are developing new approaches of intelligence information research including advanced data analysis, reasoning, inference, and interaction.

## Foundation of Software Science

—Data Analysis That Matters—

Our research focus is on advanced data analysis methods such as machine learning and data mining, and on their applications to important real-world problems in various fields including marketing, healthcare, and industrial systems. Our research interest also includes human-computer cooperative problem solving for hard problems computers alone cannot solve.

(Professor: KASHIMA Hisashi, Assistant Professor: NAKAZAWA Koji)

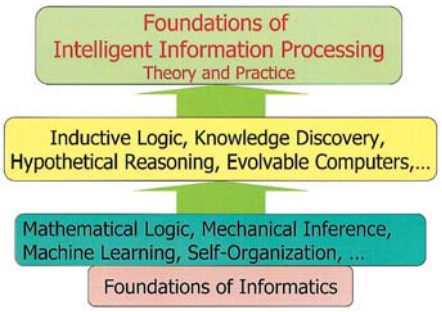



## Intelligence Information Processing Principles

—Formulation of principles to support intelligent information processing —

We will formalize intelligent information processing seen in human activities and conduct studies on basic principles which make up 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.

(Professor: YAMAMOTO Akihiro, Associate Professor: CUTURI, Marco, Assistant Professor: YOSHINAKA Ryo)




## Applied Intelligence Information Processing

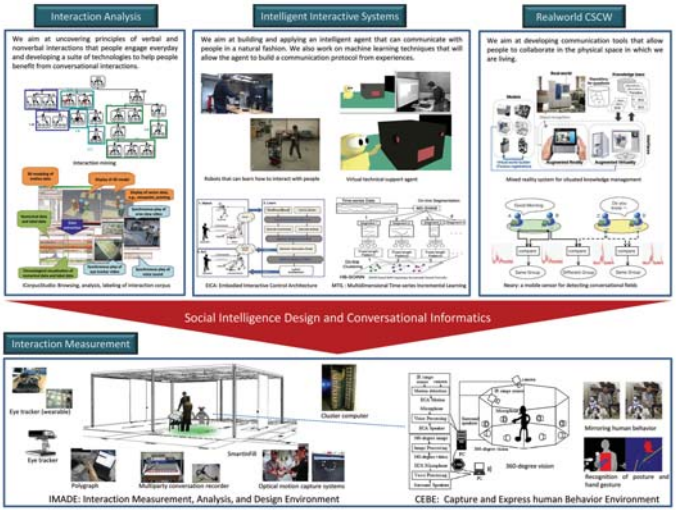
—Design and understanding of social intelligence and interaction—

Our research centers on Social Intelligence Design and Conversational Informatics. Social intelligence design is a field of research aiming at understanding and augmenting social intelligence based on a bilateral definition of social intelligence as an individual's ability to better live in a social context and a group's ability to collectively solve problems and learn from experiences. Conversational Informatics focuses on understanding of human conversational behavior as well as on the design of conversational artifacts that can interact with people in a conversational fashion. We shed light on meaning creation and interpretation resulting from the sophisticated mechanisms in verbal/nonverbal interactions during conversation, in search of better methods of computer-mediated communication, human-computer interaction, and support for knowledge creation.

Our research activities are grouped into three branches. The first focuses on interaction measurement, analysis and modeling. Major topics are IMADE (real world Interaction Measurement, Analysis and Design Environment), interaction mining, and CEBE (Capture and Express human Behavior Environment by using immersive environment). The second focuses on intelligent interactive systems. Major topics are GECA (Generic Embodied

Conversational Agents), mutual adaptation agent, EICA (Embodied Interactive Control Architecture), and MTIL (Multidimensional Time-series Incremental Learning algorithm). The third focuses on real-world CSCW. Major topics are augmented reality system to manage situated knowledge for complex instruments and PhotoChat (Communication Support System based on Sharing Photos and Hand-written Notes). The third topic is visual information understanding/synthesis about interactions including human point of gaze analysis, human vision analysis and image synthesis in virtual worlds.

(Professor: NISHIDA Toyoaki, Associate Professor: NAKAZAWA Atsushi, Assisitant Professor: OHMOTO Yoshimasa)




# Intelligence Media

The Intelligence Media Division deals with language, speech, and visual information, which are the fundamental media that represent, accumulate and communicate information. Research and education conducted at the Division cover a wide range of topics in theory and application, including analysis, recognition and understanding of information contents represented in these media, as well as media generation/editing to effectively represent and communicate information.

## Language Media Processing

—Making computers that can understand language—

Language is the most reliable medium of human intellectual activities. Our objective is to establish the technology and academic discipline for handling and understanding language, in a manner that is as close as possible to that of humans, using computers. These include the following research areas.

—Fundamental Studies on Text Understanding—

We have been developing a method for automatically acquiring linguistic patterns of predicate-argument structures. By utilizing such knowledge, we study text understanding, i.e., recognizing the relationships between words and phrases in text.

—Development of Search Engine Infrastructure based on Deep Natural Language Processing—

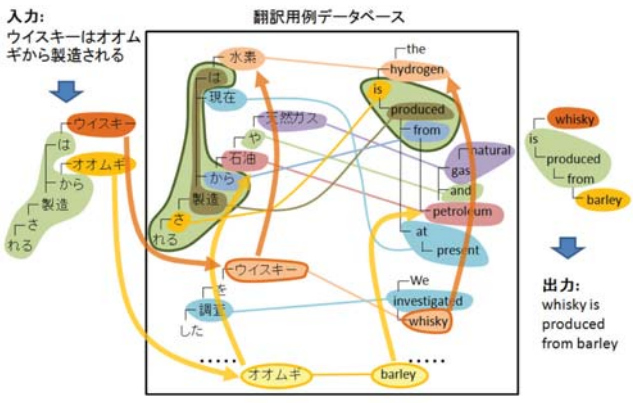
We have been developing a next-generation infrastructure of information retrieval on the basis of the following techniques of deep natural language processing: precise processing based not on

words but on predicate-argument structures, identifying the variety of linguistic expressions and providing a bird's-eye view of search results.

—Studies on Improving Machine Translation—

To bring automatic translation by computers to the level of human translation, we have been studying next-generation methodology of machine translation on the basis of text understanding and a large collection of translation examples.

(Professor: KUROHASHI Sadao, Associate Professor: KAWAHARA Daisuke, Senior Lecturer: SHIBATA Tomohide)



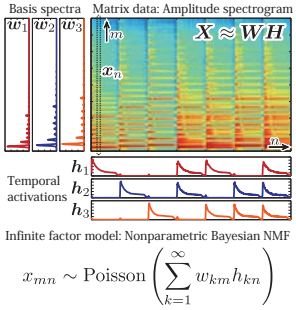

Example-based machine translation

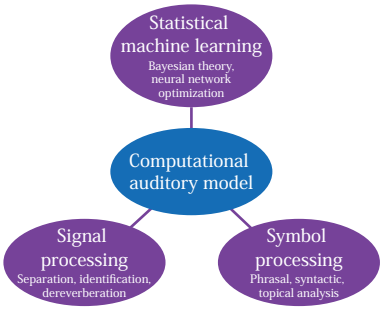
## Speech Media Processing

—Toward computer audition that can recognize and understand speech, music, environmental sounds and mixed sounds—

Our goal is to develop intelligent computers and robots that can separate, recognize, and understand various kinds of audio signals such as speech, music, and environmental sounds in terms of computational auditory scene analysis (CASA). Audition is one of the most important sensory functions of humans. We humans are capable of recognizing and understanding environmental situations and their dynamical changes by using auditory information alone or by combining it with visual and other sensory information. Is it possible to realize such an intelligent mechanism on computers? Our lab is tackling CASA based on statistical signal processing techniques. More specifically, we formulate sophisticated computational models by extending well-known general models such as nonnegative matrix factorization (NMF) and independent component analysis (ICA) to deal with complicated mixture signals that have non-linear temporal dynamics. A key feature is to actively incorporate advanced machine learning techniques such as nonparametric Bayes and deep learning and integrate high-level symbol processing for formulating flexible and robust auditory models. We also discuss computer audition in terms of cognitive science, auditory phycology, and artificial intelligence. Main research topics include music information processing, music robots, robot audition, and CASA in natural and disaster environments.

(Senior Lecturer: YOSHII Kazuyoshi, Assistant Professors: ITOYAMA Katsutoshi, NISHIDE Shun)



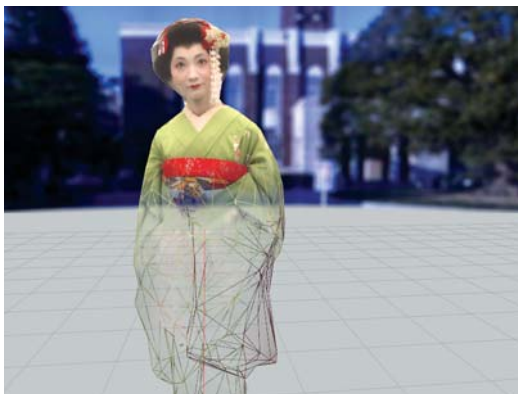




## Visual Information Processing

—Towards systems that understand visual information—

We humans are endowed with highly advanced visual perception capable of recognizing and understanding object appearances and behaviors. The goal of our education and research is to develop hardware and software technologies for systems that recognize and understand visual information as humans do. We study a 3D video technology for capturing dynamic 3D shapes and textures of people as is, a human communication system for understanding human intent and meaning behind human behavior to provide suitable information guidance, and a smart energy management system for realizing energy-efficient homes, offices, factories, and communities.

(Professor: MATSUYAMA Takashi, Senior Lecturers: KAWASHIMA Hiroaki, NOBUHARA Shohei)



3D video technology

Information Concierge System

# Computational Biology

—Toward understanding of human brain, cognition and human-machine interface

Human activities in daily life are supported by basic cognitive functions, such as perception, attention, memory or highly executive control. We investigate psychological and neuroscientific basis of these cognitive functions (especially focusing on attention and executive function), using psychological experiment, brain-imaging and computational techniques. We are interested in human behavior not only in well-controlled experimental setting in laboratory, but also in real-world setting, such as IT-equipment use and real car driving. We are also interested cognitive functions in wider range of populations from healthy young adults to older or disabled individuals.
(Professor: KUMADA Takatsune, Assistant professor: ICHINOSE Natsuhiro)

Experimental setting for touch-panel interface using eye-movement monitor.

# Application of Multimedia (Affiliated)

Multimedia processing with computer devices has new and great potential for expression, information gathering and real-time dialogue processing. We aim to teach and study the technology of multimedia applications through the construction of educational environments in which we can make use of multimedia consisting of images, texts, sound, etc. In this way, students can engage in their studies while creating something of practical use in university courses.

## Video Media

—Human-computer interaction through video media—

Computers convey information as "information media," which facilitate human communication. We are exploring “information media” technology for facilitating smooth communication through computers and aim to observe, archive and recognize human communication in intellectual activities. More specifically, we aim to achieve the following:

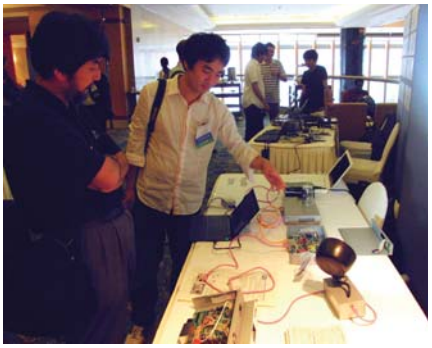
- a telepresence system for supporting human multimedia communication in the classroom;
- recognition of human activities in the kitchen to assist cooking;
- extracting 'real world information' for the protection of privacy against observation by various sensory devices;
- acquisition of shapes, motion, and colors of various objects to create virtual environments; and
- interaction between an actor and virtual objects in a virtual studio system.

(Professor: MINOH Michihiko, Associate Professor: MUKUNOKI Masayuki, Assistant Professor: FUNATOMI Takuya)


## Network Media

—Towards a ubiquitous networking world—

In a ubiquitous networking world, everything is capable of computing and networking, enabling constant Internet connectivity. Our research goal is to achieve just such an environment. For this purpose, we are working on fundamental research issues pertaining to the next-generation Internet, including IPv6 architecture, quality-aware transfer of multimedia data, mobility, zero configuration, and security. We are also working on integration technology of information, communication, and energy. We study how to apply Internet protocols and algorithms, such as routing, matching, reservation, and interruption, to power management.
(Professor: OKABE Yasuo, Associate Professor: MIYAZAKI Shuichi)

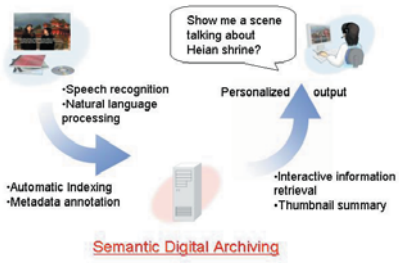


Demonstration of on-demand power network

## Media Archiving Research

—Advanced Digital Archiving through Speech and Language Technologies—

Meta-data indexing and annotation are vital for efficient access to multi-media digital archive such as lectures and meetings. We are studying speech and natural language processing oriented for this application: specifically, (1) automatic speech transcription of lectures and meetings, (2) automatic indexing and summarization, and (3) dialogue strategies for efficient access to very large archive.
(Professor: KAWAHARA Tatsuya, Associate Professor: MORI Shinsuke, Assistant Professor: AKITA Yuya)



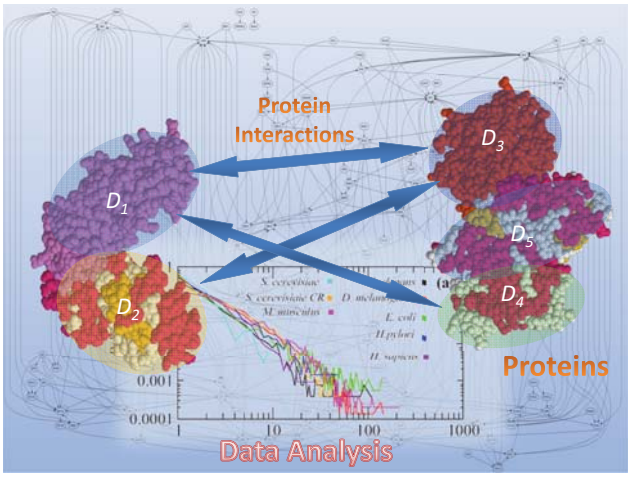

# Bio-system Informatics (Affiliated)

Biological systems and creatures are ineffably complex systems in which many kinds of chemical structures, proteins, genes and other objects interact with one another. We examine these as interactive networks to implement education and research aimed at elucidating and understanding the system, mainly from the perspective of information science.

## 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.
(Professor: AKUTSU Tatsuya, Assistant Professors: HAYASHIDA Morihiro, TAMURA Takeyuki)




Analysis of three-dimensional structures and interactions of protein

# Department of Social Informatics

## *Harmonizing Society and Information Technology*

The Department of Social Informatics seeks to clarify the structures of our highly complicated information society to actually build information systems using its techniques in the areas of global computer networks and large-scale databases, taking also into consideration the fact that autonomous decentralized information networks are taking root in our daily activities. It also supports the activities of human society that has globalized in the areas of culture, economics, environment, disaster prevention and other fields.

With Dr. Alan Kay at the Digital Library Laboratory (June 2006)

# *Education and Research on Contents and Information Access Environments as Social Information Platforms*

TANAKA Katsumi, Department of Social Informatics

Deciding how society should handle computerized information and knowledge and how to create information access environments for such information are key issues in building social information platforms for the Internet age. At the Department of Social Informatics, we have a Social Information Model Division pursuing education and research for this purpose. Our education and research focus on the technical problems related to the practical realization of social systems and their impact on society, which deal with the creation of e-governments and multimedia libraries, etc. founded on the modeling and database technologies for information and information systems scattered worldwide as well as theories of information organization and retrieval.

Society can be viewed as a distributed information system with information being generated, forwarded, accumulated and used in various locations. This information induces action and produces new information. The Distributed Information Systems Group implements education and research into systems for accumulating, managing and utilizing this distributed information. Furthermore, humankind has so far amassed vast volumes of information and knowledge in the form of libraries, magazines, and sounds as well as audio and visual recordings. The Digital Library Group has been introduced with the objective of conducting education and research to create new digital libraries by efficiently digitizing this information, organizing and structuring it into groups of knowledge, furnishing powerful search functions to cater to varying usage requirements and then supplying functions so that the information searched can be viewed and used with ease. Additionally, due to the rapid progress in information technology, greater importance has been placed on information technology to support the creation and distribution of software patents and copyrights, copyrights and design rights for multimedia information, and other intellectual properties as well as their social and legal systems. In view of this, the Information Society Group has been also set up to provide education and conduct research into the handling of intellectual property and associated information. In fiscal 2006, Keihanna Joint Graduate School was established in collaboration with Osaka University, Nara Institute of Science and Technology, National Institute of Information and Communications Technology (NICT), and NTT Communication Science Laboratories. The Knowledge Cluster Group was also set up within the department mainly to implement education and research relating to knowledge processing and information credibility.

# *Go Out from the Laboratories and Explore the Field!*

ISHIDA Toru, Department of Social Informatics

Are you mistakenly under the impression that information science is confined to the laboratories? Social informatics looks at the state of information systems in our society and goes out and analyzes a system at its actual location of use so as to come up with new ideas. For example, the Department of Social Informatics is working with an elementary school in Kyoto to develop a nature observation system that uses mobile computing technologies. Overseas, we have a base in Thailand that participates in an international project to preserve the environment, shedding light on the ecology of rare animals such as sea turtles, Mekong catfish and dugongs using the latest bio-logging techniques. Moreover, we are developing a "language grid," which allows users to use a combination of translation software and dictionaries that are registered on the Internet in collaboration with research institutes, universities and corporations worldwide with a view to overcoming language barriers. International NPOs and NGOs have already started making use of this language grid. The system is also used to provide language support to non-Japanese patients at Kyoto City Hospital and Kyoto University Hospital. Furthermore, the Department of Medical Informatics of Kyoto University Hospital and the Disaster Prevention Research Institute also participate in the Department of Social Informatics. In this way, our department drives forward with research through interaction with society and international partnerships.

# Department of Social Informatics

*Harmonizing Society and Information Technology*

# Divisions and Groups

| Division | Group | Research and Education Topics | Professor (Associate Professor) |
|---|---|---|---|
| Social Information Model | Distributed Information Systems | Technical Issues and Applications Used in the Formation of Distributed Information Systems | YOSHIKAWA Masatoshi |
| | Digital Library | Digital Contents and Information Access Architecture as Social Information Infrastructures | TANAKA Katsumi |
| | Information Society (Adjunct Unit) | Management of Intellectual Property and Associated Information | TANIGAWA Hidekazu (YAMADA Atsushi) |
| Social Information Network | Global Information Network | The Formation of Social Systems Based on Information Networks | ISHIDA Toru |
| | Information Security (Adjunct Unit) | Encryption and Authentication System | OKAMOTO Tatsuaki |
| | Market and Organizational Information Systems (Adjunct Unit) | Information Society, Information Economy, Information Policies and Corporate Information Strategies | YOKOZAWA Makoto |
| Biosphere Informatics | Bioresource Informatics | The Processing and Analysis of Biosphere Resource Data | MORIYA Kazuyuki |
| | Environmental Informatics | Investigating Interactions between Human Society and the Biosphere Environment | (KOYAMA Lina) |
| Regional and Disaster Management Information Systems (Affiliated) | Integrated Disaster Management Systems | Disaster Information Systems and Building Disaster Prevention Systems | TATANO Hirokazu |
| | Emergency Management for Disaster Reduction Systems | Social Scientific Research for Disaster Damage Reduction | YAMORI Katsuya |
| | Crisis Information Management System | Practical Disaster Management for Business Continuity | HAYASHI Haruo |
| Medical Informatics (Affiliated) | | Interaction between Information Systems and Medical and Social Organizations | KURODA Tomohiro |
| Information Fluency Education (Affiliated) | | Training People to Use Information Technology in Various Areas | KITA Hajime |
| EHR Research Unit | | Distributed Medical Information Infrastructures for Electronic Health Record and Clinical Research | (KUME Naoto) |

# Graduate Curriculum

**Courses for the Master's Program**

Social Informatics
Information System Design I
Information System Analysis
Seminar on Social Information Networks
Seminar on Disaster Prevention Informatics 1
Seminar on Disaster Prevention Informatics 3
Seminar on Information Education
Information Organization and Retrieval
Biosphere Informatics
Crisis Management
Business Information
Information Modelling
Advanced Study in Social Informatics 1
Field Informatics Seminar
Information System Design II
Seminar on Social Information Models
Seminar on Biosphere Informatics
Seminar on Disaster Prevention Informatics 2
Medical Informatics Seminar
Dispersed Information Systems
Multi-Agent Systems
Disaster and Information
Medical Informatics
Information Education
Cryptography and Information Society
Advanced Study in Social Informatics 2
Strategic Communication Seminar

**Courses for the Doctoral Program**

Advanced Seminar on Social Information Models
Advanced Seminar on Social Information Networks
Advanced Seminar on Biosphere Informatics
Advanced Seminar on Regional Disaster Prevention Information Systems
Advanced Seminar on Medical Informatics
Advanced Seminar on Information Education
Advanced Seminar on Social Informatics

# Teaching Staff

**Professors**

YOSHIKAWA Masatoshi; TANAKA Katsumi; TAJIMA Keishi (Institute of Liberal Arts and Sciences, Secondary); TANIGAWA Hidekazu (Adjunct); ISHIDA Toru; OKAMOTO Tatsuaki (NTT, Adjunct); YOKOZAWA Makoto (Nomura Research Institute, Adjunct); MORIYA Kazuyuki; TATANO Hirokazu (D, Affiliated); YAMORI Katsuya (D, Affiliated); HAYASHI Haruo (D, Affiliated); KITA Hajime (Institute of Liberal Arts and Sciences; Secondary Appointment to Academic Center for Computing and Media Studies); KURODA Tomohiro (H, Affiliated)

**Associate Professors**

MA Qiang; ASANO Yasuhito; YAMAKATA Yoko; JATOWT Adam; OHSHIMA Hiroaki; YAMADA Atsushi (ASTEM, Adjunct); MATSUBARA Shigeo; ABE Masayuki (NTT, Adjunct); KINOSHITA Takashi (Nomura Research Institute, Adjunct); ARAI Nobuaki; KOYAMA Lina; HATAYAMA Michinori (D, Affiliated); UEDA Hiroshi (M, Affiliated); KUME Naoto; TAMURA Hiroshi (H, Affiliated)

**Senior Lecturers**

KOBAYASHI Shinji; OKAMOTO Kazuya (H, Affilated)

**Assistant Professors**

SHIMIZU Toshiyuki; OGINO Hiroyuki; YAMAMOTO Takehiro; KATO Makoto; LIN Donghui (Industry-Government-Academia Collaboration); EMA Arisa (The Hakubi Project); SUZU-KI Shingo (D, Affilated); MITAMURA Hiromichi; URANISHI Yuki (H, Affiliated); MORI Mikihiko (M, Affiliated)

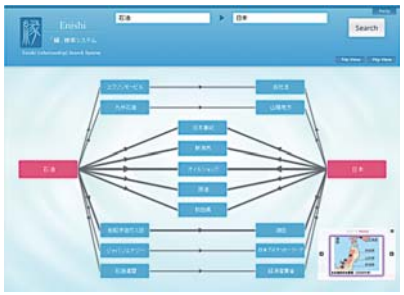
(D) : Disaster Prevention Research Institute, Kyoto University
(H) : Division of Medical Information Technology and Administration Planning, Kyoto University Hospital
(M) : Academic Center for Computing and Media Studies, Kyoto University
(ASTEM) : Advanced Scientific Technology & Management Research Institute of Kyoto

# Social Information Model

The development of information networks has enabled the widespread use of information bases distributed throughout the world. The Social Information Model Division's Groups are based around a discussion of the formation of these distributed information bases. Through a study of the creation of working social information systems such as multimedia libraries, the Groups in this Division teach and study information models of today and their possible forms in the future, covering such topics as the problems that information systems cause and their impact on society.

## Distributed Information Systems

—Society is evolving thanks to new technology that allows us to manage and utilize distributed information—



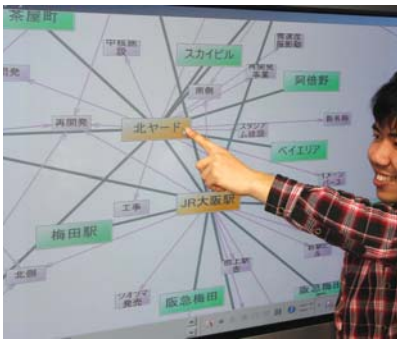
Enishi: Our system for understanding relationships

Contemporary society relies heavily upon the massive amount of information that is found mostly on the Internet. Social progress will depend upon the establishment and continuous revision of both a) technology to enable the rapid and accurate transmission of data, and b) technology to allow rapid searches of vast volumes of data to retrieve required information in a timely manner. For this reason, we will conduct basic research on databases, information retrieval, XML, Web mining, Web search, social network analysis, multimedia information systems, knowledge and scientific data management, and health/medical big data analysis. We will also conduct applied research on development of information systems better adapted to our society.

(Professor: YOSHIKAWA Masatoshi, Associate Professors: MA Qiang and ASANO Yasuhito, Assistant Professor: SHIMIZU Toshiyuki)

## Digital Library

—Aiming to create fundamental technologies for the organization, retrieval and distribution of information, and systems that will apply these technologies—




Humankind has accumulated an incredibly vast amount of information and knowledge in the form of books, magazines, voice and sound recordings, and still and moving images, to name a few. We will focus on basic research regarding the content that forms the basis of social information, and the environments in which this information is accessed. We will study ways to effectively digitize this content, organize and systematize it, and add powerful retrieval functions to meet the requirements of a wide range of applications. We will look at how to offer useful functions such as ones to recombine retrieved data into a form that makes it easier for users to read through and utilize. Our research and teaching topics cover a wide range of fields, and include databases, multimedia information systems, information retrieval, Web information systems, data mining and data visualization, content processing and digital archiving, and mobile information systems.

(Professors: TANAKA Katsumi and TAJIMA Keishi, Associate Professors: YAMAKATA Yoko, JATOWT Adam and OHSHIMA Hiroaki, Assistant Professors: YAMAMOTO Takehiro and KATO Makoto)

## Information Society Adjunct Unit

—The application of IT to social systems—

[in collaboration with the Advanced Scientific Technology & Management Research Institute of Kyoto (ASTEM) ]

With the rapid progress of information technology, there has been a corresponding rise in interest regarding the issue of intellectual property (information-based intellectual property) related to information technology, such as software patents and copyrights as well as copyrights and design rights stemming from multimedia creations. The issue of intellectual property needs to be considered from both technological and social perspectives and requires "II-type" people who are familiar with the systems and processes of not one field but many. From this perspective, we will study the handling of both information-based intellectual property and information about intellectual property by making maximum use of the methodologies of informatics and sociology and applying them to the domain of information-based intellectual property.

(Professors: TANAKA Katsumi and TANIGAWA Hidekazu, Associate Professor: YAMADA Atsushi)

# Social Information Network

Computer networks have enabled information resources unevenly spread around the world to be integrated and utilized. Today, computer networks covering the world enable us to communicate by various means, regardless of spatial or temporal constraints and this new ability is starting to influence the structure of our society. The use of these kinds of information networks will create new social information systems and contribute to social change on a global scale.

## Global Information Network

—Seeking global collaboration—

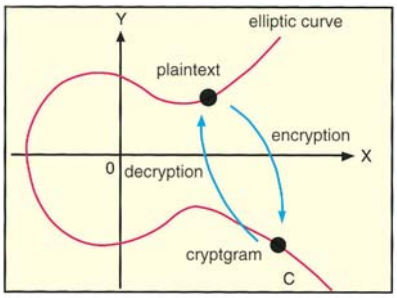
This Group aims to help Internet-based worldwide communication and collaborative activities. We will build a real social information system and conduct empirical research in the real world, then analyze the results and effects to get a better understanding of the relationship between IT and society and the best way to develop an information-networked society. Using artificial intelligence and human interface as foundations, the Group works closely with outside research organizations while undertaking information economics, and cross-cultural collaboration projects.
(Professor: ISHIDA Toru, Associate Professor: MATSUBARA Shigeo, Assistant Professors: LIN Donghui and EMA Arisa)

Youth-mediated Multilingual Support for Agriculture at Mekong Delta in Vietnam

## Information Security Adjunct Unit

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

In today's world, where the Internet is used more and more 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 safe and secure network services is becoming increasingly important. Modern cryptography is a technology to achieve this safety and 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 various applied cryptographic technologies commonly used today in public key cryptosystems, electronic cash, electronic voting and other applications, and will logically investigate their safety, present new cryptographic protocols, consider how to use them in working systems, and study their effectiveness in our networked society.
(Professors: OKAMOTO Tatsuaki and ISHIDA Toru, Associate Professor: ABE Masayuki)

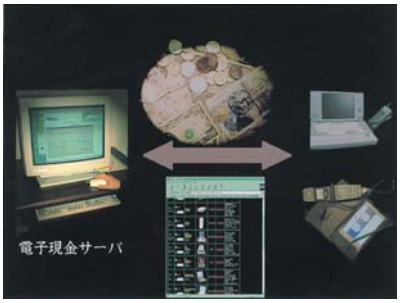



Elliptic curve cryptography

## Market and Organizational Information Systems Adjunct Unit

—ICTs for the future economy and society—
(in collaboration with Nomura Research Institute)

The Ubiquitous Network technology, the Internet of things, and cyber-physics, are changing our life. Mobile telephones, broadband Internet, near-field contact IC chips, and the software industry are all heading towards a major turning point. This unit pursues research themes regarding the reciprocal relationship between information and society, including modeling of new ICT business, cross-boarder collaboration in ICT industry, assessment of intellectual property, and social and technological innovation for sustainable industry. These studies are based on collaborative researches and experiments with a private think-tank, international organizations, industry associations, ICT companies, local communities, and virtual communities.
(Professors: YOKOZAWA Makoto and ISHIDA Toru, Associate Professor: KINOSHITA Takashi)




Experiments in digital cash

# Biosphere Informatics

There is a great variety of organisms in the biospheres from forests, farmlands to seas. These organisms have complex interrelationships, and influence our society in various ways. Our division considers the biosphere as a complex and global system, and attempts to comprehensively understand the information about individual animals, biosphere resources, and production by using the global network to gather biosphere data. We also study the influence of human activities on the global environment and human society itself through the production and management of bioresources.

## Bioresource Informatics

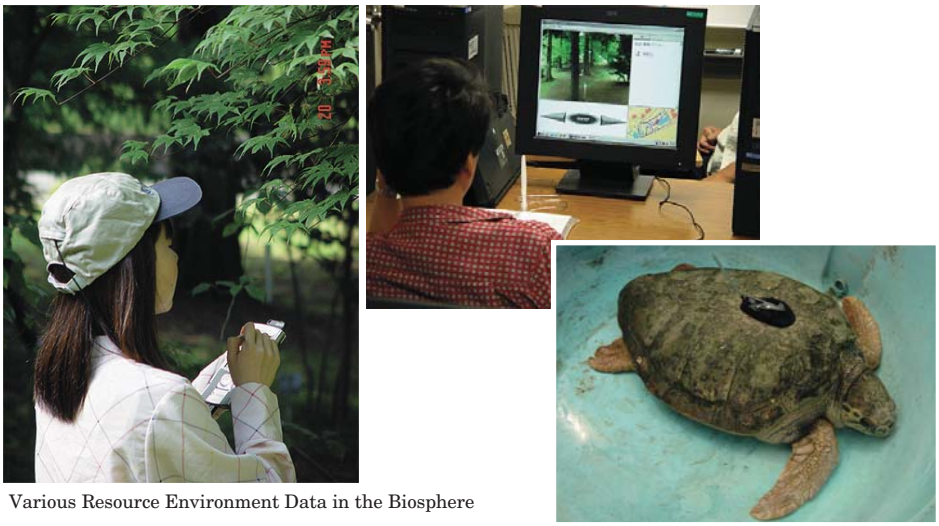
—Seeking to use information about bioresources—

This Group discusses and studies a wide range of themes including systems development for the sustainable production of bioresources, the conservation of endangered species, and the revitalization of local communities engaged in bioresource production. In order to gather and analyze the bioresource data, developed are new research methods involving the use of GPS, biotelemetry, data loggers and image analysis.
(Professor: MORIYA Kazuyuki, Assistant Professor: MITAMURA Hiromichi)

## Environmental Informatics

—Building information systems to promote coexistence between human society and the natural environment—

Environment is defined as the factors and conditions that surround organisms or human being, and relate to the activity or behavior of those subjects. Environment and its subjects, various organisms including human being, interrelate to each other, and comprise the ecosystems/biospheres. Recently, environmental change in various spatial/temporal scales has interested human society. So, this group works on the topics such as understanding/monitoring environmental information, or the role of various organisms in the ecosystems or biosphere. The development and establishment of methods to collect the information required in these fields are also our research interests.
(Associate Professor: KOYAMA Lina)



Various Resource Environment Data in the Biosphere

# Regional and Disaster Management Information Systems (Affiliated)

Disasters are abrupt and large-scale environmental changes. The natural, artificial and social environments (especially the balance among them) that have been achieved and maintained by regional communities are forced to change. If the impact of a disaster is strong enough, local communities may be unable to recover the balance they had before the catastrophe, and may be forced to create a new balance. This was demonstrated in a dramatic fashion by the catastrophic damage inflicted by the Great Hanshin-Awaji (Kobe) Earthquake and the subsequent suffering in the stricken area.

The objective of disaster prevention is to minimize the effects of disasters. Unfortunately, it is beyond our power to eliminate natural threats, such as the disasters wrought by earthquakes and typhoons. Efforts at disaster prevention help to make society more resistant to disasters by: (1) raising our ability to foresee and predict the threat of natural disasters; (2) raising our ability to keep the damage in check; and (3) minimizing the effects of the damage.

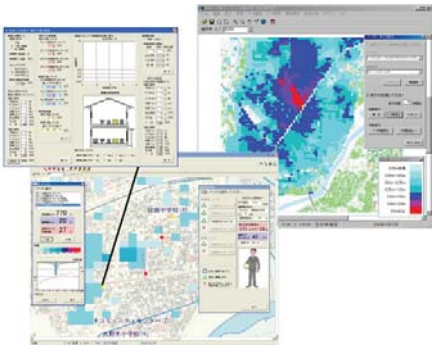
Disasters are the greatest obstacle to the sustainable development of humankind. According to figures from the International Red Cross, disasters annually take the lives of 130,000 people and cause $US440 billion in damage. Population growth is driving urbanization. Societies are becoming more complex and diverse. At the same time, disasters are growing in scale and frequency. One could say that society's ability to withstand disasters is rapidly diminishing.

Information processing lies at the heart of disaster prevention. This Division will focus primarily on disaster prevention in urban areas and will teach students about the establishment of information systems designed to achieve "urban disaster reduction" that both minimizes the immediate effects of disasters and prevents their aftermath from lingering for too long a time.

## 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.
(Professor: TATANO Hirokazu, Associate Professor: HATAYAMA Michinori)



Flood Risk Communication Support System

## Emergency Management for Disaster Reduction Systems

—Social scientific research for disaster damage reduction—

The research in our group is aimed at reducing the destruction caused by major disasters, from social scientific points of view, particularly, from the perspective of social psychology. We do action researches at several research fields both in Japan and overseas. Our practical and theoretical researches are related with the following topics, disaster psychology, disaster risk communication, disaster education, regional crisis management, and disaster information.
(Professor: YAMORI Katsuya, Assistant Professor: SUZUKI Shingo)


Disaster education materials developed in our lab

## Crisis Information Management System

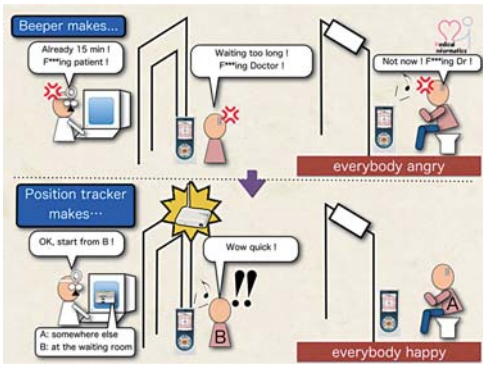
—Clarifying how disaster responses work in terms of the information processing process—

In the wake of a disaster, people learn new behaviors in response to the new reality and need a process through which their positions can be accepted in society. Responding to a disaster is an information processing process in which individuals and society have to decide how to comprehend and respond to the reality of what has happened. Our research seeks to gain a better understanding of the information processing process through which people respond to disasters, based on the Business Continuity Management framework of 1) risk assessment, 2) strategic planning, 3) standardized risk management systems, and 4) training that seeks to reduce peoples' suffering caused by disasters.
(Professor: HAYASHI Haruo)

Simulation of the earthquake and tsunami of the 1944 Tonankai Earthquake

# Medical Informatics (Affiliated)

—Illustrate future of clinical medicine of information age—




Although nobody performs any modern clinical medical activity without computational support, the current clinical system is still maladjusted to the Information Revolution. The Medical Informatics Laboratory tries to illustrate future of clinical medicine of the information age through research activities to implement information platforms for, to analyze clinical information of, and to provide feasible information support for the existing clinical fields including Kyoto University Hospital. Our research includes any topics interfacing medicine and informatics, such as Clinical System Development (Ubiquitous Hospital Information Systems, Telemedicine Systems, Epidemiology Information Platforms), Clinical Data Analysis (Hospital Administration Management, Clinical Data Mining, Medical Image Processing), and Information Support Applications (Hospital Administration Simulation, Computer Aided Diagnosis, Clinical Decision Support, VR-based medical education).
(Professor: KURODA Tomohiro, Associate Professor: TAMURA Hiroshi, Senior Lecturer: OKAMOTO Kazuya, Assistant Professor: URANISHI Yuki)

# Information Fluency Education (Affiliated)

—Striving for new forms of information education—

Information education provides an important nexus between information and society. In the past it was known as "information literacy" and focused mainly on developing students' skills in applying information technology. There is an increasing need for the application of IT to many academic fields and social issues, and it is very important to educate people about the basic concepts of information usage and to foster their intelligent information-use skills so that they can apply information technology. This is what we call "information fluency education." In the Information Fluency Education Division, we use the educational computer systems of the Kyoto University Institute for Information Management and Communication to teach and research in the fields of information education (to train people to use IT in a range of areas), artificial intelligence to support education and learning, the application of information security technology, the systematization of education content, and education methods and assessment techniques.
(Professor: KITA Hajime, Associate Professor: UEDA Hiroshi, Assistant Professor: MORI Mikihiko)

# EHR Research Unit

—Pioneering the frontier of Electronic Health Record (EHR) —

Current information science leads a new era, which provides new knowledge with massive data stream analysis. To extend the possibility of treatment and clinical study outcome, infrastructure of medical information should mediate information sources beyond the border between health and disease. The EHR Research Unit aims to achieve personalized healthcare information infrastructure by research collaboration with multiple domain companies; information technology (IT) service consultation, medicine manufacture, laboratory testing services, and caregiving services.

Collaborative research companies: GlaxoSmithKline, LSI Medience Corporation, NTT DATA Corporation, SRL, Inc., Tokyo Midtown Medicine Co, Ltd.
(Associate Professor: KUME Naoto, Senior Lecturer: KOBAYASHI Shinji, Professor: YOSHIKAWA Masatoshi)

# Department of Applied Analysis and Complex Dynamical Systems

## *Toward the Analysis and Synthesis of Varied Behavior of Complex Systems*

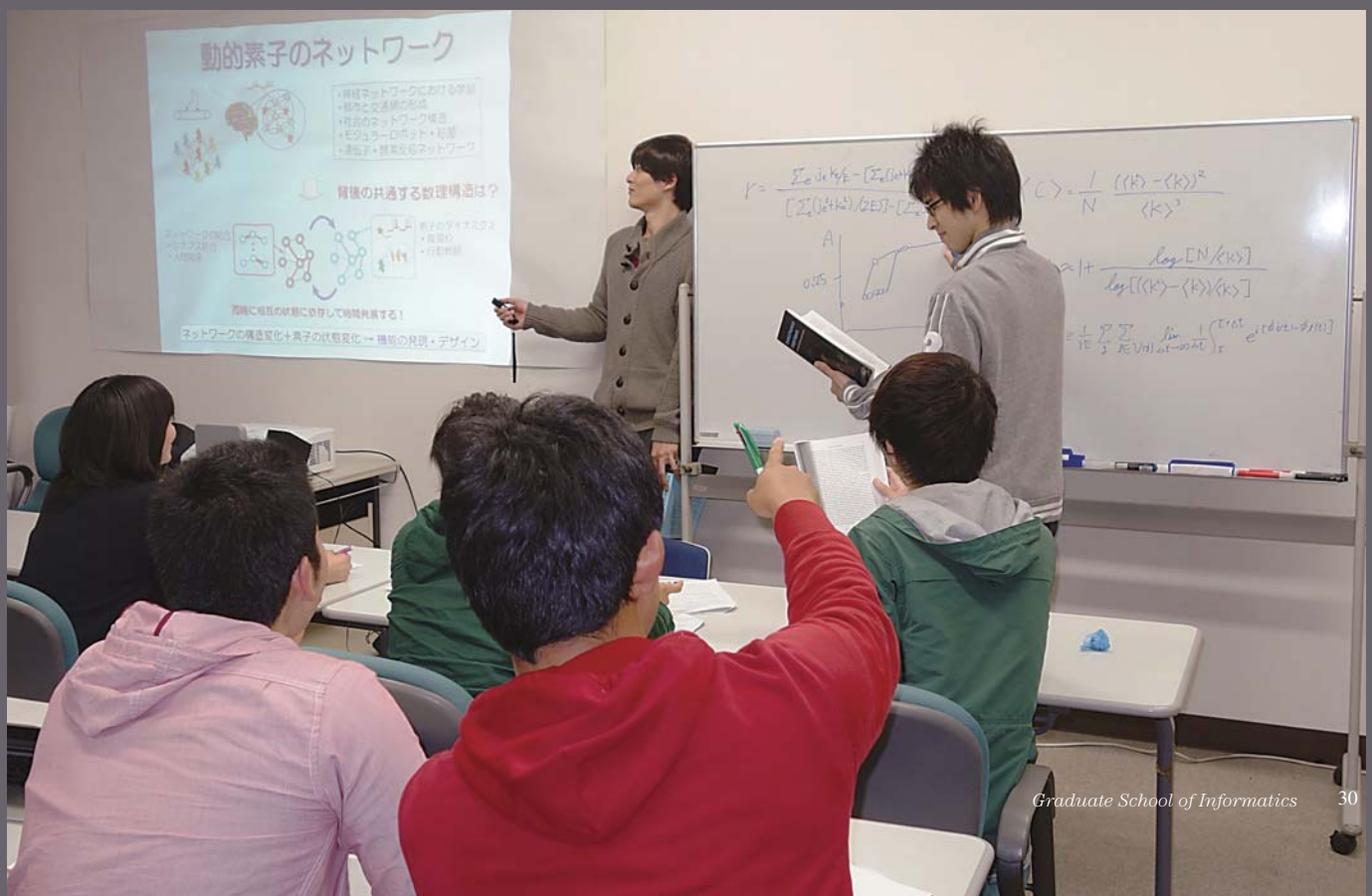
Complex systems refer to systems that exhibit, as a whole, a variety of behavior and functions such as self-organization, chaos with a large degree of freedom, and learning and associative memories through nonlinear large-scale interactions among those elements. This department aims to clarify the fundamental principles and structures of these complex systems, analyze and extract useful information from this huge mass of information, and design suitable systems. We undertake education and research related to the clarification of solution structures for complex mathematical models by way of mathematical and numerical analysis, development of models and solution algorithms for chaos in complex dynamics, nonlinear phenomena such as pattern formation, and complex systems, as well as system control, intelligence, and self-organization.

# *An Invitation to the Department of Applied Analysis and Complex Dynamical Systems*

FUNAKOSHI Mitsuaki, Department of Applied Analysis and Complex Dynamical Systems

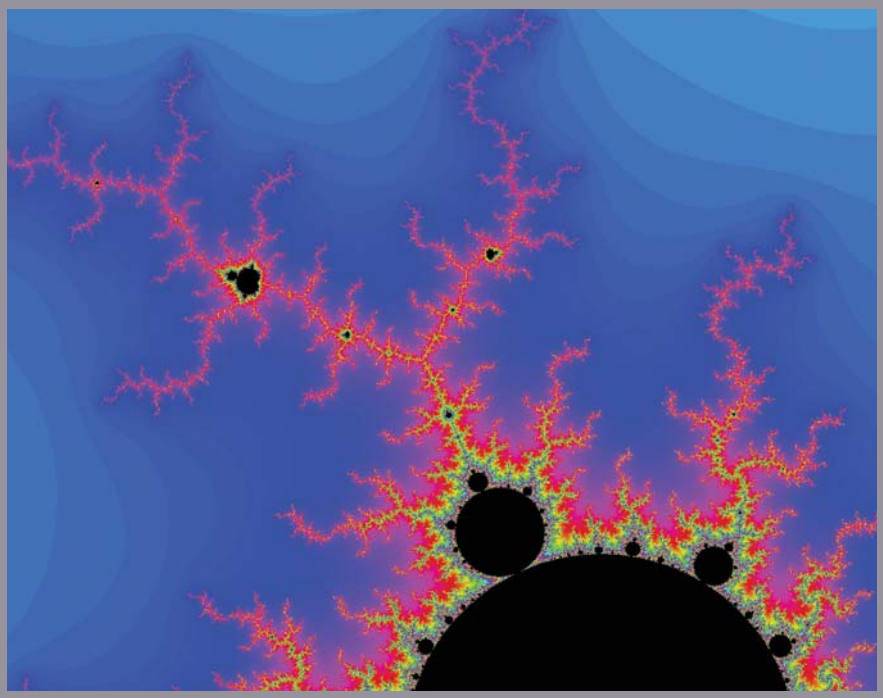
Applied Analysis and Complex Dynamical Systems Science is a discipline which strives to explain complex phenomena that could not be understood or utilized fully on simplified mathematical models in the past by using various computers and analysis based on new concepts such as chaos and fractals. In particular, our department focuses on systems that are sensitive to strong nonlinearity, a high degree of freedom, large scales, and errors in order to fuse together engineering perspectives with scientific perspectives based on mathematics, numerical calculations, nonlinear physics, sample data control theory, etc. In other words, we hold in esteem the respective values of both science, which represents the pursuit of "reason," and engineering, which represents the art of "craftsmanship." Both in terms of our research and education, effort is made to mutually compensate for the drawbacks of each of these aspects to truly combine science and engineering.

With faculty members who are also comprised of graduates from both science and engineering fields, the department has three divisions: Applied Analysis, Complex Dynamics, and Applied Mathematical Sciences. Each of these divisions operates under the keywords "applied analysis," "nonlinear physics," and "engineering" in their educational and research activities. More specifically, both basic and applied education and research is conducted primarily on fluids, elastic bodies, and neural systems that display strong large-scale or nonlinear characteristics, separating these into fields such as differential equation, numerical analysis, probability theory, fractal analysis, nonlinear dynamics, fluid dynamics, statistical mechanics, computational dynamics, control theory, and digital signal processing.



# Department of Applied Analysis and Complex Dynamical Systems

## *Toward the Analysis and Synthesis of Varied Behavior of Complex Systems*



## Divisions and Groups

| Division | Group | Research and Education Topics | Professor |
|---|---|---|---|
| Applied Analysis | Applied Analysis | Analysis of Inverse and Ill-posed Problems, Non-linear Problems, Analysis on Fractals, Numerical Analysis, Partial Differential Equation, Harmonic Analysis, Scientific Computation | ISO Yuusuke<br>KIGAMI Jun |
| Complex Dynamics | Nonlinear Dynamics | Fluid Dynamics, Computational Physics, and Nonlinear Oscillators | FUNAKOSHI Mitsuaki |
| | Nonequilibrium Dynamics | Theoretical Neuroscience, and Network Science, Nonequilibrium or Nonlinear Physics, and Network Dynamical Systems | |
| Applied Mathematical Sciences | Computational Mechanics | Computational Mechanics and Monte Carlo Simulations | NISHIMURA Naoshi |
| | Intelligent and Control Systems | System Control, Digital Signal Processing, Modelling, and System Design Theory | YAMAMOTO Yutaka |

## Graduate Curriculum

**Courses for the Master's Program**

Applied Analysis A
Applied Analysis B
Complex Dynamics A
Complex Dynamics B
Applied Mathematical Sciences A
Applied Mathematical Sciences B
Topics in Differential Equations A
Topics in Differential Equations B
Topics in Nonlinear Analysis A
Topics in Nonlinear Analysis B
Seminar on Applied Analysis I
Seminar on Applied Analysis II
Topics in Applied Analysis I
Topics in Applied Analysis II
Topics in Nonlinear Dynamics A
Topics in Nonlinear Dynamics B
Topics in Nonequilibrium Dynamics A
Topics in Nonequilibrium Dynamics B
Seminar in Complex Dynamics I
Seminar in Complex Dynamics II
Topics in Complex Dynamics I
Topics in Complex Dynamics II
Topics in Computational Mechanics A
Topics in Computational Mechanics B
Topics in Control Theory A
Topics in Control Theory B
Seminar in Applied Mathematical Sciences I
Seminar in Applied Mathematical Sciences II
Topics in Applied Mathematical Sciences I
Topics in Applied Mathematical Sciences II
Advanced Study in Applied Analysis and Complex Dynamical Systems I
Advanced Study in Applied Analysis and Complex Dynamical Systems II

**Courses for the Doctoral Program**

Seminar on Applied Analysis and Complex Dynamical Systems (Advanced)
Seminar on Applied Analysis (Advanced A & B)
Seminar on Complex Dynamics (Advanced A & B)
Seminar on Applied Mathematical Sciences (Advanced A & B)

## Teaching Staff

**Professors**
ISO Yuusuke; KIGAMI Jun; FUNAKOSHI Mitsuaki; NISHIMURA Naoshi; YAMAMOTO Yutaka
**Associate Professors**
AOYAGI Toshio
**Senior Lecturers**
KUBO Masayoshi; WAKANO Isao; MIYAZAKI Syuji; YOSHIKAWA Hitoshi; NAGAHARA Masaaki
**Assistant Professors**
FUJIWARA Hiroshi; KANEKO Yutaka; TUTU Hiroki; HARADA Kenji; NIINO Kazuki

# Applied Analysis

Applied mathematics seeks to go far beyond the mere application of pure mathematics to the solution of physical and mechanical problems. Through research into mathematical models of phenomena, applied mathematics creates new mathematics. Our Division teaches and carries out research in applied analysis where there is particular emphasis on analysis in fields of applied mathematics. We seek to improve our understanding of existing analytics and create new analytics for the 21st Century. To give specific examples of the kinds of research we do, we analyze mathematical models of physical and mechanical phenomena by applying mathematical and numerical analysis and stochastic theory to get a better understanding of both the analytical methods and the mathematical structure of the model, and to establish new analytical techniques. In this Division, the key words are "nonlinear analysis" and "inverse problem analysis," and our full-time teaching staff constantly interacts with one another while they teach and conduct research.

## Nonlinear Analysis and Inverse Problem Analysis

—Analysis in the 21st Century—

Faculty Members and Their Research Interests

**ISO Yuusuke (Professor)**

***Numerical Analysis of (Partial) Differential Equations, Numerical Analysis of Ill-posed Problems, Analysis of Inverse Problems***

I carry out both mathematical and numerical analysis 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.

**KIGAMI Jun (Professor)**

***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.

**KUBO Masayoshi (Senior Lecturer)**

***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.

**WAKANO Isao (Senior Lecturer)**

***Numerical Analysis of (Partial) Differential Equations, Partial Differential Equations, Mathematical Research in Fracture Mechanics***

I am involved in research into the mathematical and numerical analysis of partial differential equations in mechanics. Recently, I have carried out numerical calculations of problems in the field of fracture mechanics.

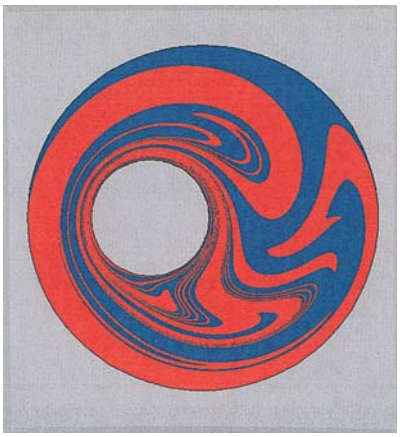
**FUJIWARA Hiroshi (Assistant Professor)**

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

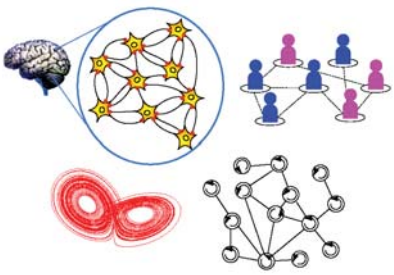
I am involved in research concerning regularization methods and numerical analysis of multiple-precision calculations with the aim of solving inverse problems that occur in mechanics and geophysics and reconstructing them numerically.

# Complex Dynamics

The dynamic behavior of systems that have a high degree of freedom and engage in nonlinear mutual interactions is both complex and richly diverse, and yet, many of these systems possess qualities in common with each other, such as a regular structure, and are fascinating subjects for research. In this Division, we use logical analysis and computer simulations to gain a better understanding of the complex behavior and control of these kinds of dynamic systems, as well as to clarify their common principles.



An efficient mixture of fluids is attained if two cylinders, one inside the other, are rotated slowly in opposite directions so that each fluid particle moves chaotically. This is called chaotic mixing.



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. At first glance, these systems might appear to be completely different, but the invariant structure that they both have may be hidden. Mathematical models are useful tools to help us understand these systems.

## Fluid Dynamics and Computational Physics

—Studies of the complex behavior of fluids and other nonlinear dynamic systems—

We aim to understand and control the various patterns of complicated behavior of nonlinear dynamical systems such as fluid systems, many-particle systems, and structural systems. In particular, we are trying to clarify, control and utilize in fluid systems and coupled dynamic systems the nonlinear behavior of chaos, synchronization, pattern formation, generation and interaction of nonlinear waves, interaction of vortices, and thermal convection. To achieve this aim, we conduct logical analysis based on the theory of nonlinear dynamic systems, reduction theory, and singular perturbation methods, and apply simulation techniques such as differential calculation, spectral methods, Monte Carlo techniques, and molecular dynamic methods. Our teaching and research also covers the development of techniques to analyse the reliability and risk concerning the failure of structural systems from the perspective of the application of stochastic process theory and stochastic field theory, and the use of computer simulations and theory relating to crystal growth and surface properties.
(Professor: FUNAKOSHI Mitsuaki, Assistant Professor: KANEKO Yutaka)

## Nonequilibrium Physics and Theoretical Neuroscience

—From nonlinear and non-equilibrium physics to theories on networks as well as living and neural systems—

Physical systems like fluids and chemical reactions are not the only cooperative phenomena that are made up of comparatively simple elements, and yet exhibit complex behavior and advanced functions that are impossible to predict from the individual elements alone. This same characteristic is also found in neural systems and social phenomena. For example, in neural systems, the mutual interaction between the basic elements called neurons all grouped together allows the neural system to acquire the advanced information processing functions of learning, memory and decision-making, or from a more ordinary perspective, they form the dynamic elements in a network (neurons, cities, people, etc.). The network structure and dynamic activity of the elements are simultaneously changing, and the network exhibits the ability to organize itself. Our research looks at these kinds of cooperative phenomena that have multiple elements, and focuses on reduction theory, rhythmic phenomena, and chaos theory from the perspective of nonlinear dynamics and non-equilibrium physics.
(Associate Professor: AOYAGI Toshio, Senior Lecturer: MIYAZAKI Syuji, Assistant Professor: TUTU Hiroki)

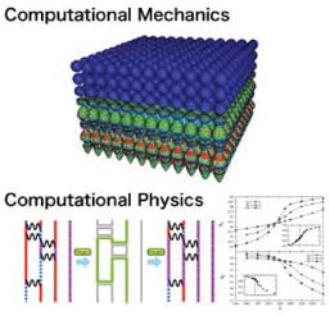
# Applied Mathematical Sciences

Many of the objects that we study in mechanics are large and complex, and often exhibit behavior that is uncertain and difficult to predict. Although the most important issue for us is to be able to accurately predict this behavior and control it, this is generally not easy to do. High-speed simulation techniques are essential to the prediction and analysis of large, complex systems; and in order for us to be able to control complex systems, the control method we use has to take into account the indefinite nature of the system and the uncertainty of its behavior — i.e., the method of control has to be robust. In our Division, we develop and apply these techniques from the standpoint of applied mathematical science.

## Computational Mechanics

—Computer simulations: from the development of high-speed computation to the understanding of quantum systems—

Numerical simulations are a powerful tool to help us solve many different kinds of problems in science and engineering. Computational mechanics, together with theoretical and experimental mechanics, is an effective method for investigating mechanical phenomena in engineering. Our Group is developing the Boundary Integral Equation Method (BIEM), a major technique in computational mechanics that is particularly effective in the analysis of waves and fractures. We are conducting research into fast BIEMs and their applications to large-scale problems. We are also working to solve periodic problems so we can apply the results to studies — particularly, in optical science. We are carrying out research into simulations of macroscopic phenomena (quantum phase transitions, etc.) that are governed by quantum mechanics and the algorithms that are used in these simulations.
(Professor: NISHIMURA Naoshi, Senior Lecturer: YOSHIKAWA Hitoshi, Assistant Professor: HARADA Kenji, Assistant Professor: NIINO Kazuki)




Example of analysis using a time domain fast multi-pole boundary integral equation method (top) ; an algorithm to stochastically sample a quantum state (bottom)

## Intelligent and Control Systems

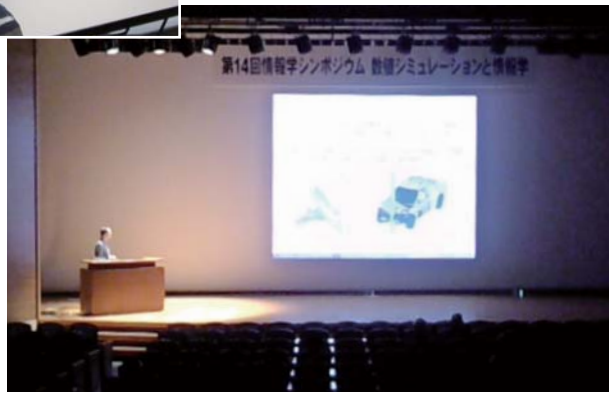
—Controlling systems and signal processing—

We are surrounded by a vast number of systems in daily life: natural systems such as water cycles and the weather, and man-made systems ranging from satellites, aircraft and computer networks to robots, production systems, and small electronic devices. For all these systems to function properly, there has to be some kind of control mechanism at work. It is desirable that the control mechanisms of man-made systems work in a more sophisticated and intelligent manner. In our Group we carry out theoretical and advanced applied research into digital robust control, signal processing systems, network systems, and other areas to make control systems more advanced and intelligent, and improve voice processing as well as still- and moving-image processing.
(Professor: YAMAMOTO Yutaka, Senior Lecturer: NAGAHARA Masaaki)

A high-performance DA converter for CDs, designed using sampled-data control theory. It recovers and recreates sounds up to a frequency of 150 kHz and can create a sound quality close to that of the acoustics of a concert hall.

# Departmental Activities

The Department of Applied Analysis and Complex Dynamical Systems deals with studies including development of novel analytical techniques for the new academic filed of complex systems science, investigation of order-forming characteristics in complex systems, modeling and control of complex dynamical systems, and function design for complex mechanical systems. In particular, in cooperation with the Department of Mechanical Engineering and Science, the Department of Micro Engineering, and the Department of Aeronautics and Astronautics of the Graduate School of Engineering, as well as the International Innovation Center, we promoted education and research in the field of mechanical engineering at the "Research and Education on Complex Functional Mechanical Systems — New Developments in Mechanical Engineering Inspired by Complex Systems Science" Center for research and education (FY2003-2007) as part of the 21st Century Center of Excellence (COE) Program. Following this program, we have been promoting education and research for expansive relationship between science and engineering. Recently, we organized a symposium entitled "New Frontier in Complex Systems Science — From theory to practice" at Kyoto University in June, 2012. In this symposium, we had an opportunity to have lectures that give a broad understanding of our researches to general public as well as applicants for admission to doctoral course. Also, we organized the 14th Informatics Symposium (February 2013) entitled "Numerical Simulation and Informatics," in which two staffs of the department gave talks on numerical simulation.



# Department of Applied Mathematics and Physics

## *Engineering/Natural Systems: Modeling, Analysis, Operation, Design and Solution*

In the highly advanced information society today, we encounter various situations that entail modeling, analysis, planning, control and operation of complex and large-scale systems. In these situations, it is extremely important to figure out 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 eight laboratories of the Department of Applied Mathematics and Physics undertake leading-edge researches on applied mathematical analysis, discrete mathematics, system optimization, control systems theory, applied mathematical modeling (adjunct unit), physical statistics, dynamical system theory, and mathematical finance (affiliated division).

# *Modeling and Control: Describing and Manipulating Systems*

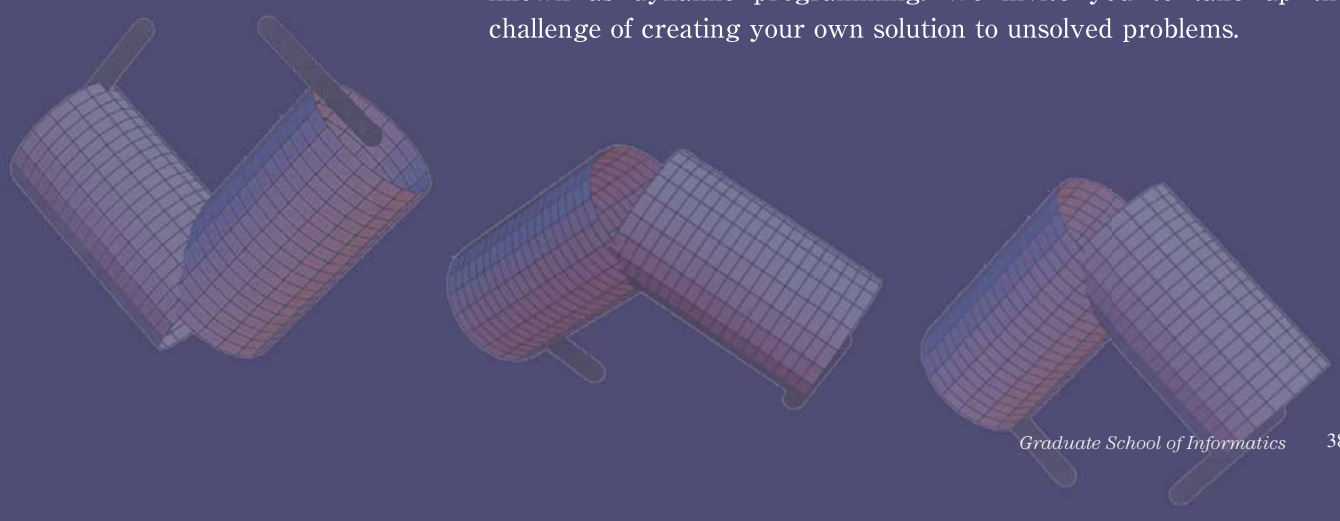
OHTA Yoshito, Department of Applied Mathematics and Physics

The science of control is the study of trying to manipulate the movement of various things, from mobile vehicles such as automobiles and aircraft to production systems for the steel production process. For example, preventing vibration on robot manipulators is also a control task. We need to extract characteristics that are important to control from a control object that displays complex movements, create a model, and use that model to come up with a control rule to produce the desired movement. We invite you to expand the field of application for the science of control and have a go at developing new modeling methods and control rules.

# *Optimization of Discrete Structures*

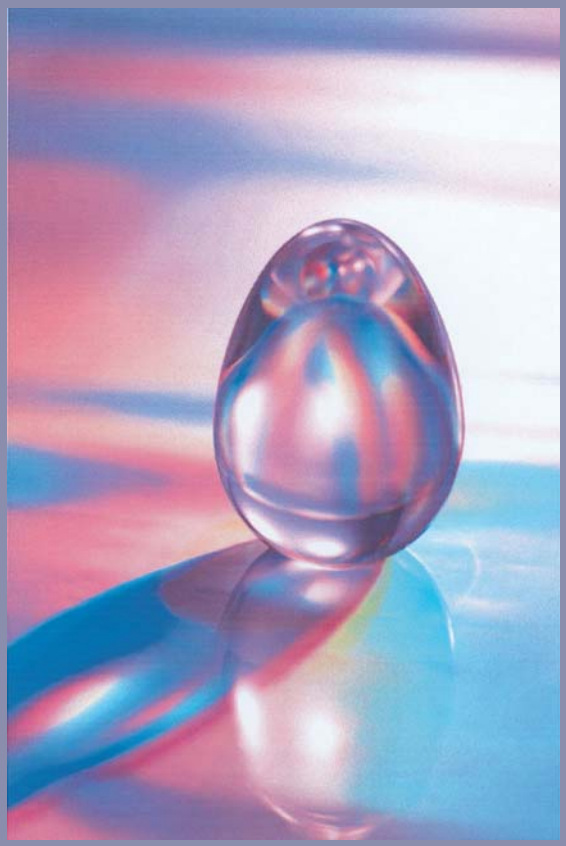
NAGAMOCHI Hiroshi, Department of Applied Mathematics and Physics

The objective of applied mathematics and physics is to create a model to explain phenomena that are seemingly intangible and to formulate "theories for actual use" that can produce optimum answers to problems. In this regard, my laboratory deals with problems that have discrete structures. For instance, it would take an enormous amount of time to check all possible routes between two points on a map. However, we can produce a solution for instantly identifying the shortest route between those two points if we were to use a theory known as dynamic programming. We invite you to take up the challenge of creating your own solution to unsolved problems.



# Department of Applied Mathematics and Physics

*Engineering/Natural Systems:*
*Modeling, Analysis, Operation, Design and Solution*



## Divisions and Groups

| Division | Group | Research and Education Topics | Professor |
|---|---|---|---|
| Applied Mathematics | Applied Mathematical Analysis | Applied Integrable Systems and Numerical Algorithms | NAKAMURA Yoshimasa |
| | Discrete Mathematics | Theory and Application of Discrete Optimization, Graph Theory, and Discrete Algorithms | NAGAMOCHI Hiroshi |
| Applied Mathematical Systems | System Optimization | Optimization Theory & Algorithms and Operations Research | |
| | Control Systems Theory | Systems Control Theory, System Identification and Large-scale and Stochastic Dynamical Systems | OHTA Yoshito |
| | Applied Mathematical Modeling (Adjunct Unit) | Applied Mathematical Modeling and Social Information Systems Modeling | YAMAMOTO Akira |
| Mathematical Physics | Physical Statistics | Physical Statistics, Basic Theory of Nonlinear and Complex Systems, and Stochastic Process Fundamentals and Applications | UMENO Ken |
| | Theory and Applications of Dynamical Systems | Dynamical Systems, Ordinary and Partial Differential Equations, and Mathematical Physics | YAGASAKI Kazuyuki |
| Mathematical Finance (Affiliated) | | The Science of the Functional Efficiency of Finance | |

## Graduate Curriculum

**Courses for the Master's Program**

Operations Research (Advanced)
Systems Analysis (Advanced)
Mathematical Analysis (Advanced)
Control Systems Theory (Advanced)
Physical Statistics (Advanced)
Financial Engineering
Advanced Study in Applied Mathematics and Physics I
Advanced Study in Applied Mathematics and Physics II
Mathematical Physics (Advanced)
Topics in Applied Mathematics and Physics A, B
Discrete Mathematics (Advanced)
Optimization Theory (Advanced)
Introduction to Mathematical Finance
Dynamical Systems (Advanced)

**Courses for the Doctoral Program**

Seminar on Applied Mathematics (Advanced)
Seminar on Applied Mathematical Systems (Advanced)
Seminar on Mathematical Physics (Advanced)
Seminar on Applied Mathematics and Physics (Advanced)
Seminar on Mathematical Finance (Advanced)

## Teaching Staff

**Professors**

NAKAMURA Yoshimasa; NAGAMOCHI Hiroshi; OHTA Yoshito; YAMAMOTO Akira (Hitachi, Ltd., Adjunct); UMENO Ken; YAGASAKI Kazuyuki

**Associate Professors**

TSUJIMOTO Satoshi; YAMASHITA Nobuo; KASHIMA Kenji; FUKUMOTO Takashi (Hitachi, Ltd., Adjunct); IGARASHI Akito; KIMURA Kinji (Program-Specific Associate Professor)

**Assistant Professors**

KAMIOKA Shuhei; SEKIDO Hiroto (Program-Specific Assistant Professor); FUKUDA Hidemi; OHKI Kentaro; MINAMI Yuki (Program-Specific Assistant Professor); SATO Akihiro; YAMAGUCHI Yoshiyuki

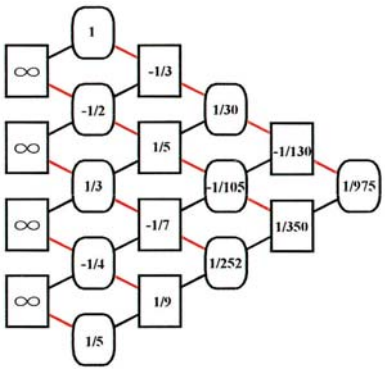
# Applied Mathematics

This Division consists of two Groups: first, the Applied Mathematical Analysis Group, which carries out research into the applied analysis of the tremendous range of functions and the mathematics of algorithms and other integrable and discrete integrable systems; and second, the Discrete Mathematics Group, which studies combination problems, graph and network problems, logical functions, discrete optimization, and other topics. The Applied Mathematics Division teaches and conducts research in many topics, including the creation of new mathematical models, the development of algorithms, the understanding of the complexity of mathematical computation, and system modeling.

## 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.
(Professor: NAKAMURA Yoshimasa, Associate Professors: TSUJIMOTO Satoshi , Program-Specific Associate Professor: KIMURA Kinji, Assistant Professor: KAMIOKA Shuhei, Program-Specific Assistant Professor: SEKIDO Hiroto)

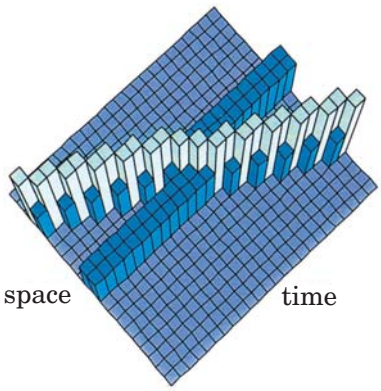



$\eta$ -algorithm (discrete KdV equation)

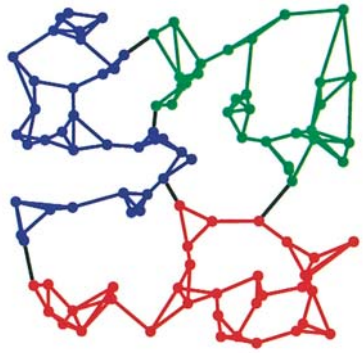
## Discrete Mathematics

—Exploring the complexity of discrete mathematics problems and developing algorithms—

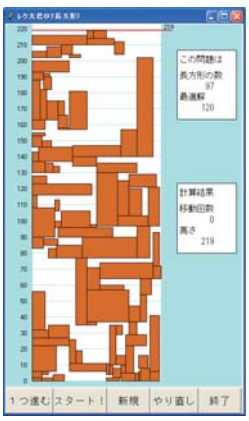
Topics in discrete mathematics, such as the graphs and network used to represent systems, schedules to enhance the efficiency of production, and the logical analysis of large volumes of data, are closely related to applications of research results. We explore the complexity of the calculations used to solve these problems; design exact/approximation algorithms; develop taboo search algorithms, genetic algorithms and other metaheuristic algorithms; and apply them to solving actual problems.
(Professor: NAGAMOCHI Hiroshi)

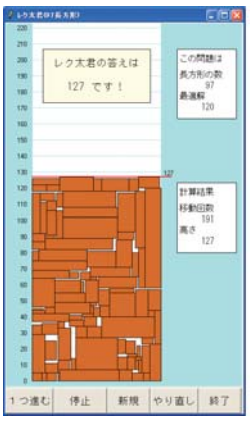



Ultra-discrete soliton



Computation of a minimum cut that separates a network into three components with the same number of vertices

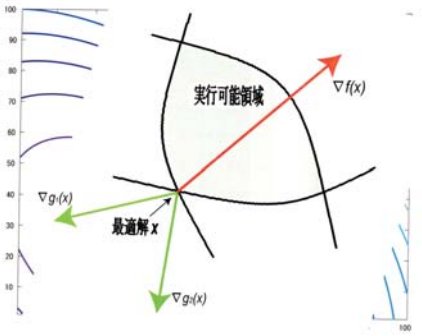





A puzzle in which you have to fit the pieces into a box of fixed width without any of the rectangular pieces overlapping and try to make the height of the packed pieces as low as possible (left). Illustrations of the calculations performed by "Rekuta-kun," a packing solution developed at the Applied Mathematics and Physics Laboratory: start (middle) and final result (right).

# Applied Mathematical Systems

We carry out education and research regarding mathematical theories that are used in the analysis, planning, management and evaluation of a wide range of complex systems that occur in a computer-networked society and in modern production systems. Examples of these theories include mathematical programming, applied probability theory, network theory, modern feedback control theory, estimation and identification of probability systems, and robust control theory. We also apply these theories in the development of problem-solving algorithms. In an adjunct unit, we also engage in education and research for applying various methodologies in real-world systems.



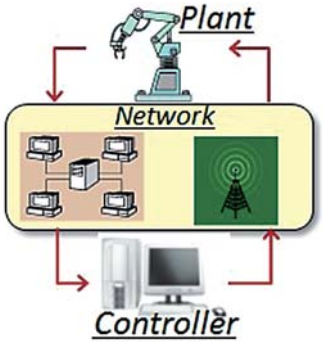

Karush-Kuhn-Tucker Condition

## 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.

(Associate Professor: YAMASHITA Nobuo, Assistant Professor: FUKUDA Hidemi)



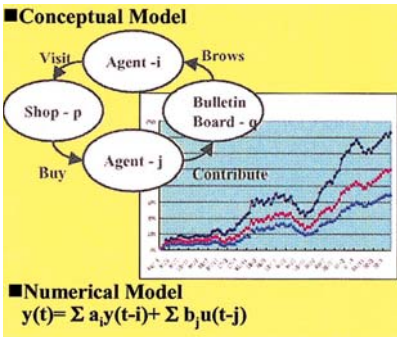

A sketch of networked control systems

## 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 control symthesis, control systems with input/output constraints, networked control systems, algebraic system theory, mathematical optimization in control, stochastic realization, system identification, model reduction of large scale systems, hybrid control and quantum control theory.

(Professor: OHTA Yoshito, Associate Professor: KASHIMA Kenji, Assistant Professor: OHKI Kentaro, Program-Specific Assistant Professor: MINAMI Yuki)




## Applied Mathematical Modeling Adjunct Unit

—Infusing information systems with intelligence —

(in collaboration with Hitachi, Ltd.)

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).

(Professor: YAMAMOTO Akira, Associate Professor: FUKUMOTO Takashi )

# Mathematical Physics

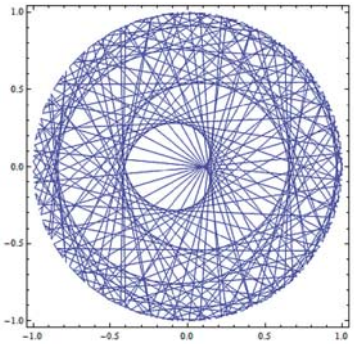
We look into mathematical models in physics, chemistry and biology that form the foundations of engineering and investigate those models in a dynamical system perspective by applying methods developed in statistical physics, dynamical systems theory, differential equations, probability theory, stochastic process theory, and computer simulation; and we conduct applied research with the goal of gaining a better understanding of their mathematical structure and building fundamental theories.

## 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 system. 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.
(Professor: UMENO Ken, Associate Professor: IGARASHI Akito, Assistant Professor: SATO Akihiro)

**Various coupled multi-element systems**



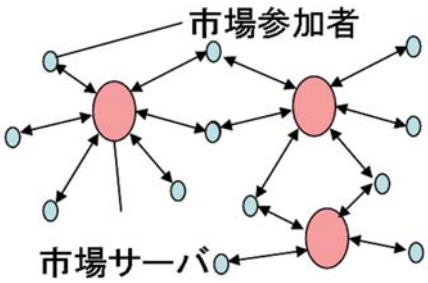
Chaos code for signal analysis and multi-user communications system

A conceptual diagram of a complex network

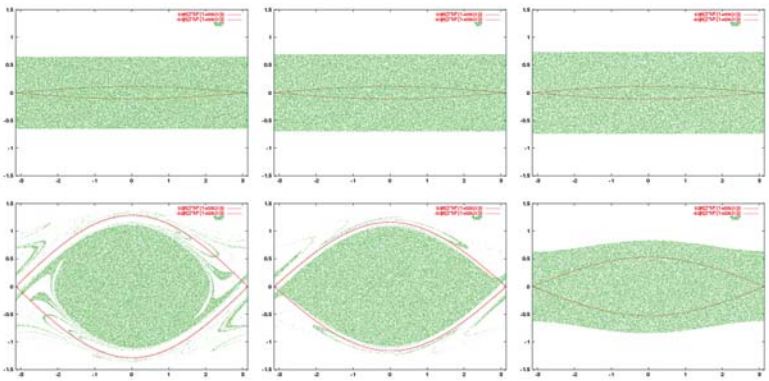
## Theory and Applications of Dynamical Systems

—Looking into systems through dynamical systems theory—

Our research purpose is that using dynamical systems approaches, we analyze complicated phenomena such as chaos and bifurcations in various systems appearing in sciences, engineering and other disciplines, and apply them to develop novel engineering technologies. For this purpose, we not only use standard approaches but also establish new innovative theories in dynamical systems. Moreover, we utilize numerical approaches such as verifiable computation and large-scale numerical simulation, and study nonintegrability of dynamical systems and differential equations, nonlinear waves in partial differential equations, and kinetic theory of many-body systems.
(Professor: YAGASAKI Kazuyuki, Assistant Professor: YAMAGUCHI Yoshiyuki)

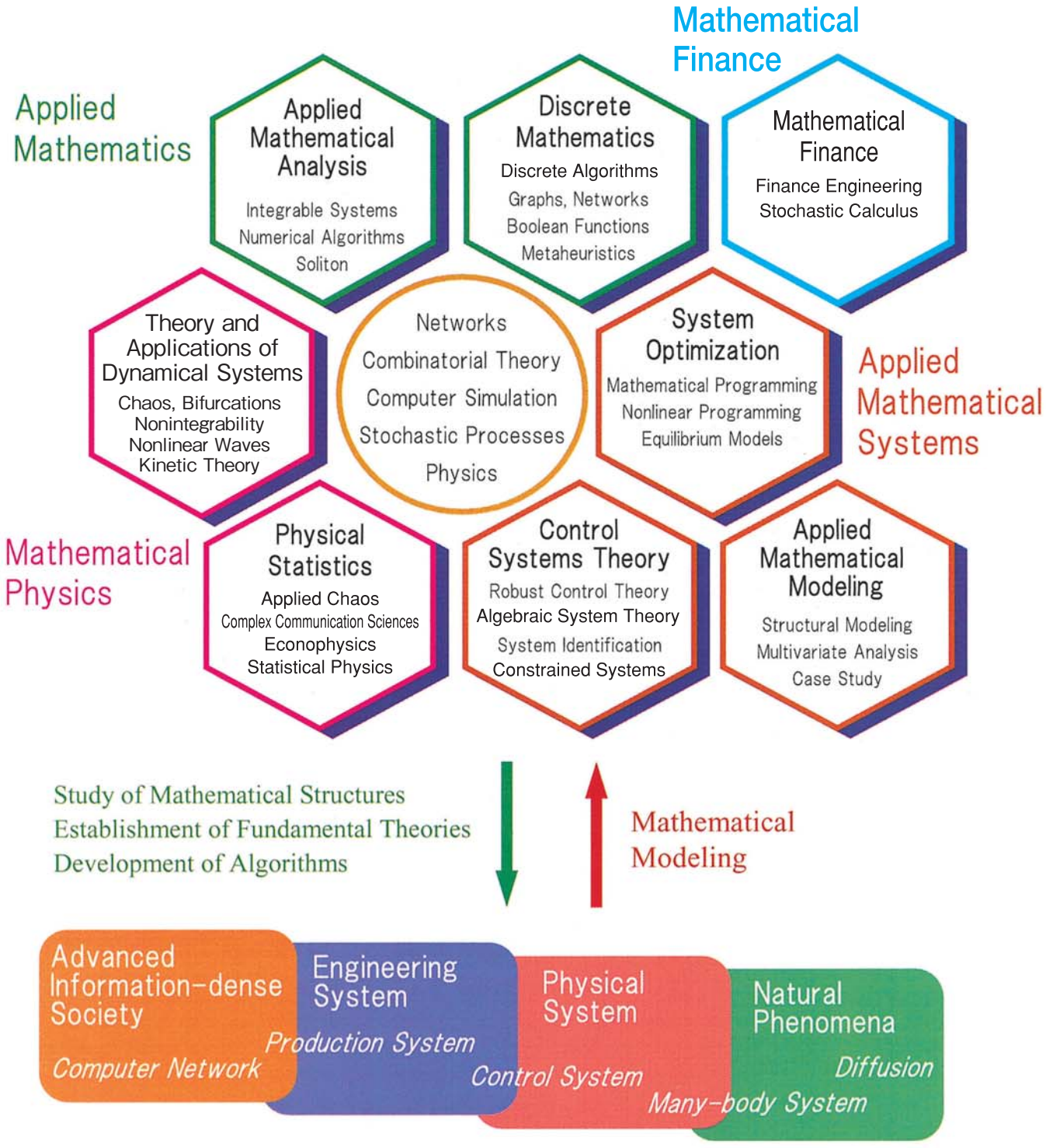



A model of the financial market and the market participants



Nonequilibrium phase transition slight modification of initial states (upper) results large difference after temporal evolution clower.

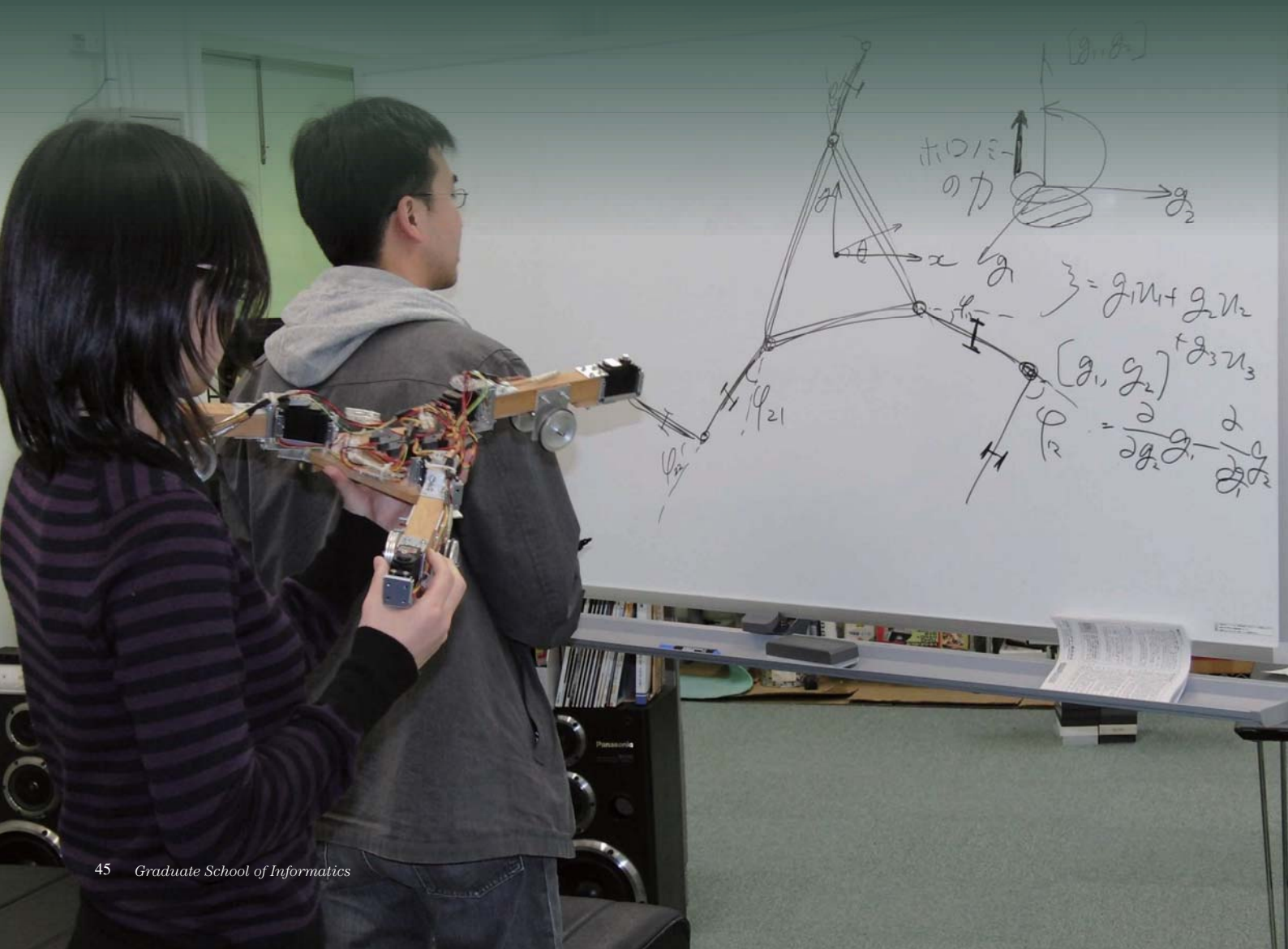
# Department of Applied Mathematics and Physics



# Department of Systems Science

## *New Frontier in Informatics and Systems*

Research and education in the Department 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 the understanding of complicated mutual interactions among human-beings, systems and environments.



# *Information System Used in Medical Science and Treatment*

MATSUDA Tetsuya, Department of Systems Science

In the modern world, information communications technology is applied to various fields and the medical field is not an exception among them. Hospital information systems such as electronic medical records, diagnostic systems such as medical images, and treatment assistance systems such as surgical robots are used in hospitals. In this way, information communications systems have become an indispensable part of modern medicine. Information technology also contributes to numerous aspects of progress in basic medical research that aims to understand various physiological and pathological conditions by investigating the human body and its cells or molecules. Our Biomedical Engineering Laboratory in the Department of Systems Science directs applied research that is directly associated with medical treatment by way of developing medical education assisting systems and medical imaging devices and basic research called systems biology that attempts to understand the biological phenomena by considering the body as a system. A diverse range of studies based on the keywords “medical science” and “information science” is conducted in our laboratory by introducing cutting-edge information technology and theories into these fields. To satisfy your intellectual interests through research at our laboratory, we welcome anyone who is interested in state-of-the-art information systems that contribute to the fields of medicine, medical treatment, and biology.

# *Systems Science is Interesting!*

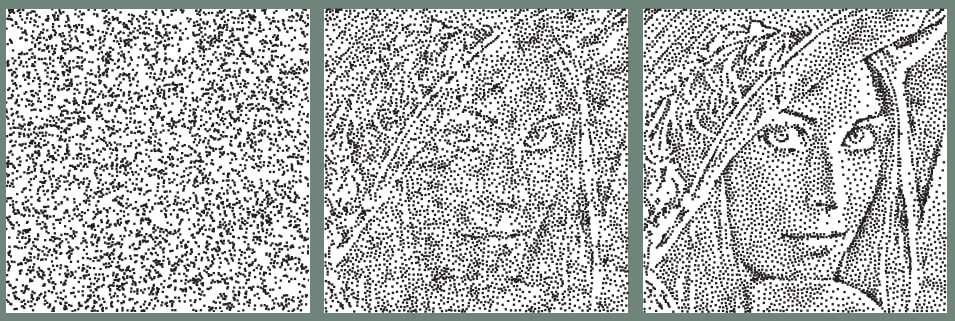
TANAKA Toshiyuki, Department of Systems Science

"Systems Science" is a very interesting academic field. There is no clear definition, but I believe that the quintessence of systems science lies in our "attitude" toward perceiving and analyzing the intrinsic structure of matters as well as solving problems. Our study subjects range over a wide variety of problems. For instance, our laboratory conducts research into the theoretical performance analysis of wireless communication systems as well as the mining (structure extraction) of WWW online store data. However, all our research is founded on "machine learning"—namely, imparting artificial systems with the functionality to learn, infer, and adapt. This demonstrates that problems which appear completely different may often share an essential structure. The best part of systems science is that it will vastly widen your perspective by enabling you to recognize these facts, and this is what makes it so interesting.

Addressing a diverse range of issues requires not only basic academic knowledge, but also "instinct" for accurately grasping the essence of a problem. The "instinct" you will acquire by tackling specific issues individually will no doubt help you greatly when you go out into the world. Acquiring a balance of knowledge and "instinct," and broadening your outlook on the basis of it. If you find such an approach to pursuing problems interesting, you are welcome at the Department of Systems Science.

# Department of Systems Science

## New Frontier in Informatics and Systems



## Divisions and Groups

| Division | Group | Research and Education Topics | Professor |
|---|---|---|---|
| Human Machine Symbiosis | Mechanical Systems Control | Advanced Control Theories and Their Application to Mechanical Systems | SUGIE Toshiharu |
| | Human Systems | Human-Centered System Design, Modeling, Virtual Sensing, and Control | KANO Manabu |
| | Symbiotic Systems | Nonlinear Systems Theory, Optimal Control, Real-Time Optimization, Human-Machine Systems | OHTSUKA Toshiyuki |
| System Synthesis | Adaptive Systems Theory | Adaptive, Learning, and Inference Theories and Their Application | TANAKA Toshiyuki |
| | Mathematical System Theory | Mathematical Systems, Signal Processing, and Wireless Communications | |
| | Computational Intelligence Systems (Adjunct Unit) | Data Mining and Pattern Recognition Based on Statistical Machine Learning | UEDA Naonori |
| Systems Informatics | Information Systems | Mathematical modeling and Performance Analysis Methodologies of Information Systems and Their Application | TAKAHASHI Yutaka |
| | Integrated Systems Biology | Modeling of Intelligence (Brain) and Life, and Its Application | ISHII Shin |
| | Biomedical Engineering | Information Systems for the Medical Field | MATSUDA Tetsuya |
| | Computational Neuroscience (Adjunct Unit) | Computational Neuroscience, Brain Network Interface | KAWATO Mitsuo |
| | | Neural Circuit Information Processing, Neural Information Code | FUKAI Tomoki |
| | | Basal Ganglia, Neuromodulators, Evolutionary Robotics | DOYA Kenji |
| Applied Informatics (Affiliated) | | Supercomputers and High-Performance Parallel Processing | NAKASHIMA Hiroshi |

## Graduate Curriculum

**Courses for the Master's Program**

Control Theory for Mechanical Systems
Modeling and Problem-Solving of Complex Systems
Theory of Symbiotic Systems
Statistical Systems Theory
Theoretical Life-Science
Supercomputing (Advanced)
Industrial Mathematics and Design
Advanced Study in Systems Science 2
Theory of Human-Machine Systems

Adaptive Systems Theory
Theory of Information Systems
Medical Information Systems
Advanced Study in Systems Science 1

Systems Sciences (Advanced)

**Courses for the Doctoral Program**

Seminar on Systems Science (Advanced)
Seminar on Systems Synthesis (Advanced)
Seminar on Applied Informatics (Advanced)
Seminar on Human Machine Symbiosis (Advanced)
Seminar on Systems Informatics (Advanced)

## Teaching Staff

**Professors**

SUGIE Toshiharu; KANO Manabu; OHTSUKA Toshiyuki; TANAKA Toshiyuki; UEDA Naonori (NTT, Adjunct); TAKAHASHI Yutaka; ISHII Shin; MATSUDA Tetsuya; KAWATO Mitsuo (ATR, Adjunct); FUKAI Tomoki (RIKEN, Adjunct); DOYA Kenji (OIST, Adjunct); NAKASHIMA Hiroshi (M)

**Associate Professors**

AZUMA Shun-ichi; NISHIHARA Osamu; HAYASHI Kazunori; MASUYAMA Hiroyuki; NAKAO Megumi

**Senior Lecturers**

OBA Shigeyuki; OHKUBO Jun

**Assistant Professors**

MARUTA Ichiro; HIRAOKA Toshihiro; FUJIWARA Koichi; OHZEKI Masayuki; KANEKO Megumi; MASUYAMA Hiroyuki; MAEDA Shin-ichi; SHIMAYOSHI Takao; HIRAISHI Tasuku (M)

(M) : Academic Center for Computing and Media Studies

# Human Machine Symbiosis

As computer networks spread and information systems become more sophisticated, the interrelationship between manmade systems (typified by machines) and humankind and the environment (including the natural environment and our social environment) is becoming ever more complicated and diverse. So we aim at making the relationships between machines, humankind, and nature harmonious and stable, while being able to cope with complexity and diversity. To this aim, we clarify both the principles and the methodologies of relationship building theoretically, by taking a wide range of approaches that encompass systems theory, control engineering, artificial intelligence, cognitive science, human interface technology, robotic engineering, and reliability engineering. Based on these studies, we build various types of concrete systems.

## Mechanical Systems Control

—Aiming to design robust and flexible mechanical systems—

A robot arm with 7 degrees of freedom

Advanced control methods that can operate mechanical systems properly under adverse conditions are necessary in order to built systems that have the flexibility to adapt to, and the robustness to withstand, environmental change. Our group focuses on developing this kind of advanced control theory. We also conduct education and research regarding the application of such theory in mechatronics and robotic engineering. More concretely, our theoretical research topics include robust control, system modeling, saturated systems, nonlinear systems, and hybrid systems. Application examples of our research include magnetic levitation systems, crane systems, inverted pendulums, airship control, snake-like robots, and biological systems.
(Professor: SUGIE Toshiharu, Associate Professor: AZUMA Shun-ichi, Assistant Professor: MARUTA Ichiro)

## Human Systems

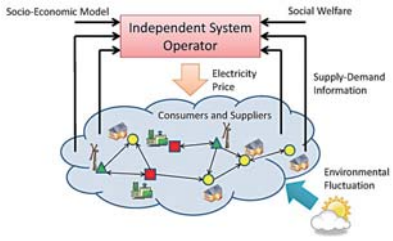
—Aiming to Develop Human-Centered System Design Methodology—

Human-Centered System Design

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.
(Professor: KANO Manabu, Associate Professor: NISHIHARA Osamu)

## Symbiotic Systems

—Toward harmonious coexistence of a diversity of systems—

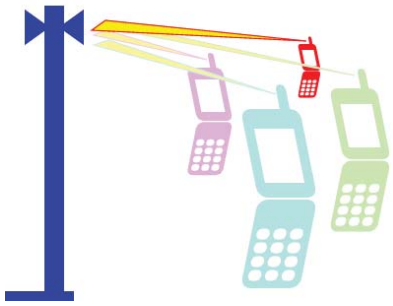



A system consisting of humans, machines, societies, and environments

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 systems. To this end, we conduct researches on novel methodologies to deal with nonlinearities and dynamic optimization, 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.
(Professor: OHTSUKA Toshiyuki, Assistant Professor: HIRAOKA Toshihiro)

# System Synthesis

For intelligent systems, acquisition of information about themselves and their surroundings is prerequisite to attainment of their self-stabilization and enhancement of their own functions. The division performs education and research from the standpoint of applied mathematics for solving a variety of problems in Systems Synthesis: artificial realization of adaptive and learning abilities in humans and the living things as well, and modeling and information processing for exploring systems' advanced functions.

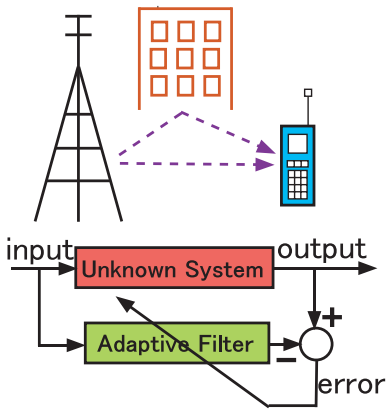


Digital communications as data mining: How one extracts the desired information from many intermixed signals is the key to high-performance digital communications.

## Adaptive Systems Theory

—Theoretical approaches to systems that learn and adapt—

We aim to create artificial systems that have the ability to learn, infer, and adapt — like animals and humans do — and are involved in education and research that focuses on various theoretical problems that will have to be overcome for this to happen. Specifically, with interests in the application to artificial intelligence, pattern recognition, data mining, digital information communication, we conduct research into theories of probability-based inference and learning, which explains the efficient acquisition of useful information in an uncertain environment, and the statistical mechanics of information processing, which can be discussed by drawing an analogy between the information mathematics of large-scale probability models and statistical mechanics.
(Professor: TANAKA Toshiyuki, Senior Lecturer: OHKUBO Jun, Assistant Professor: OHZEKI Masayuki)




General framework for adaptive filters

## Mathematical System Theory

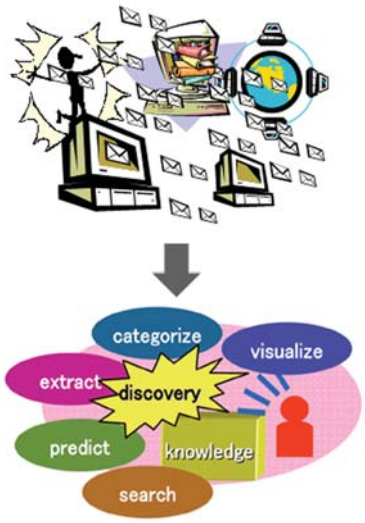
—For better understanding of mathematical systems theory through stochastic and statistical approaches—

Our research and teaching involve the building and analysis of stochastic and statistical models that appear in various systems, and the development of effective algorithms needed for the practical application of these solutions in the real world. In particular, based on signal processing, which provides a framework for extracting useful information from observed raw data, we carry out education and research on various systems especially in the field of telecommunications, such as mobile wireless communications systems and high-speed optical communications systems.
(Associate Professor: HAYASHI Kazunori, Assistant Professor: KANEKO Megumi)

## Computational Intelligence Systems Adjunct Unit

—Data Mining & Pattern Recognition Based on Statistical Machine Learning—

Data mining is the technology which discovers significant latent relationships, rule, patterns from huge amount of data like Web contents. It has been widely used in many recommendation systems for products already. We are pursuing statistical machine learning approach to provide highly sophisticated data mining technologies to extract, classify, organize, visualize, and predict latent information hidden in the data. We will offer education and research opportunities in this field.
(Professors: UEDA Naonori and TANAKA Toshiyuki)




Latent information extraction, classification, organization, visualization, and prediction from huge amount of data

# Systems Informatics

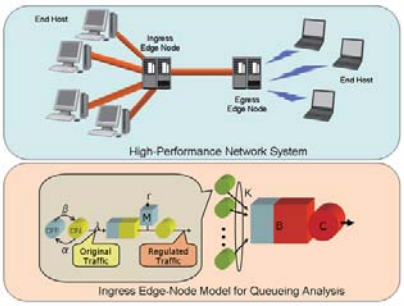
The division performs the education and research from the standpoints of systems science and information science for solving a variety of problems in various kinds of practical systems. Current education and research program is concerned with communication systems, brain and neural systems, and systems in biomedical engineering. We have concerns about practical systems but also theoretical approaches.

## Information Systems

Research interests in the group include mathematical modeling and theoretical analysis of performance issues arising in information and communication systems, transportation systems, and manufacturing systems. Current activities are concerned with the following and related topics:

1. Modeling and performance analysis of information and communication systems
2. Queueing (Traffic) theory and its application to computer communication systems
3. Management and control of autonomic networking
4. Stochastic analysis of discrete event systems.
5. Performance evaluation of wireless/mobile networks.

(Professor: TAKAHASHI Yutaka, Associate Professor: MASUYAMA Hiroyuki)

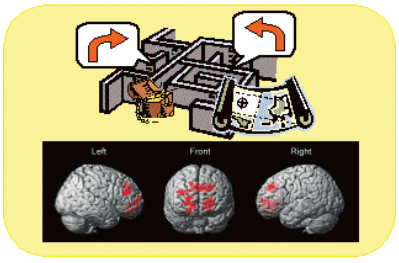



Theoretical model for the analysis of high-speed network systems

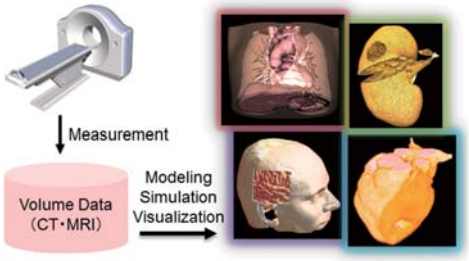
## Integrated Systems Biology

—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.
(Professor: ISHII Shin, Senior Lecturer: OBA Shigeyuki, Assistant Professor: MAEDA Shin-ichi)




A model of the decision-making process in an uncertain environment, and images of information processing within the brain



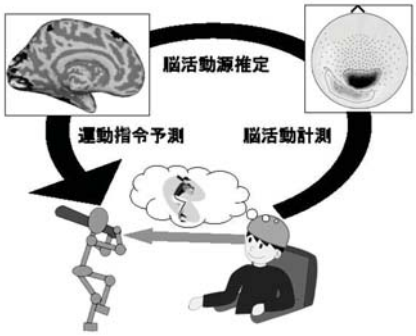

Volume manipulation and visualization for diagnosis and surgery

## Biomedical Engineering

—Learning about 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 simulation systems of biological functions, medical imaging techniques, and innovative methods to measure physical characteristics of human bodies.

(Professor: MATSUDA Tetsuya, Associate Professor: NAKAO Megumi)




## Computational Neuroscience Adjunct Unit

—Create a brain in order to understand the brain—

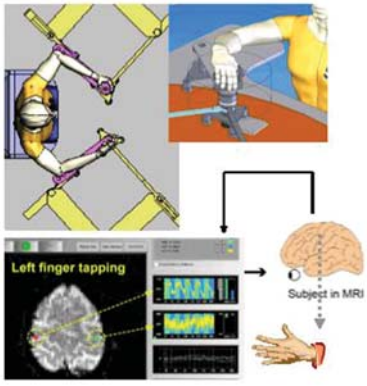
(a) Humanoid Robot

The goal of our study is to control robots by thoughts in the brain. This study is expected to contribute to the connection of humans and robots as a future telecommunication device and to the development of an assistive device for the recovery of motor functions in humans. We aim to understand brain mechanisms especially those of motor control.

(b) Brain Machine Interface

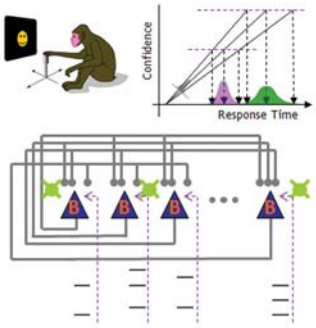
We aim to understand the brain function through computational neuroscience and to develop a Brain Machine Interface (BMI) for recovery of motor functions in humans as technology for IT and clinical applications.

(Professors: KAWATO Mitsuo and ISHII Shin)



## —Neural Circuit Information Processing—

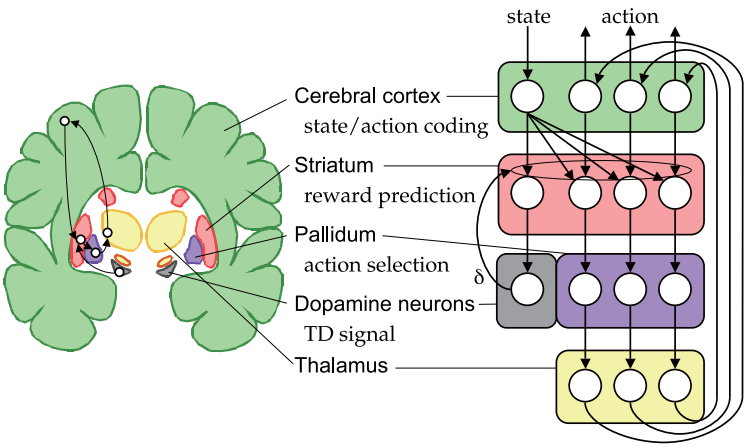
Neuronal networks play a central role in information processing by the brain. To uncover the principles governing the computation by the brain, we perform theoretical analysis of neural network models, construction of microcircuit models of the brain, and development of mathematical tools for deciphering neural code.Moreover, we will develop and use methods in non-linear dynamical systems, stochastic process, probabilistic inference and machine learning. Furthermore, we give motivated students an interdisciplinary research opportunity to learn theories and applications of brain information processing.
(Professors: FUKAI Tomoki and ISHII Shin)




A neuronal network model for perceptual decision making inferred from activity of the monkey brain

## —Computational theory of action learning and the brain's mechanisms for learning—

Humans and animals can learn varieties of behaviors under novel, uncertain environments. What is the brain's mechanism for such flexible learning? Its understanding requires integration of the computational theory of action learning and the dynamics of the networks of the neurons, molecules, and genes in the brain. Our laboratory works on the algorithms of reinforcement learning and Bayesian inference, their implementation to robotics and bioinformatics, neural recording from rats' basal ganglia and the brain stem, human brain imaging, and evolution of learning capabilities in a robot colony. We welcome members from a variety of countries and disciplines to enjoy research in the campus overlooking the ocean of Okinawa.
(Professors: DOYA Kenji and ISHII Shin)




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

# Applied Informatics (Affiliated)

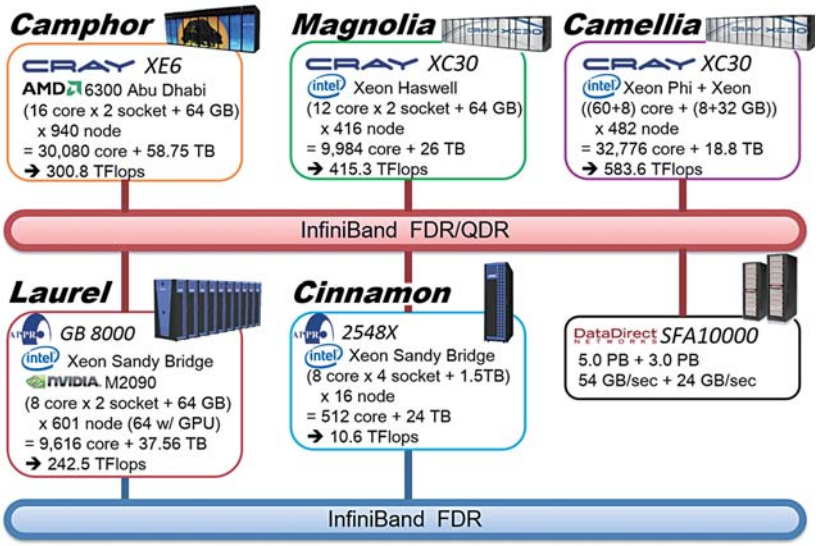
(Academic Center for Computing and Media Studies)

We carry out fundamental and applied research regarding parallelization and high-performance computing technologies that hold great promise for supercomputing at the frontiers of science. We also look at ways to put this research into practical use. We work on research projects with researchers from various scientific fields that need large-scale simulations and scientific computation, as well as with researchers involved in supercomputer technology within the university and in the wider scientific community. Our students are learning a wide range of high-performance computing technologies, from the design of software for parallelized applications to high-performance hardware.

(Professor: NAKASHIMA Hiroshi, Assistant Professor: HIRAISHI Tasuku)

—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. We are studying the basic technologies for high-performance parallel processing, such as parallel systems that link together many computers, languages that simplify parallel processing, and software libraries that can be widely used in a range of fields. 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.

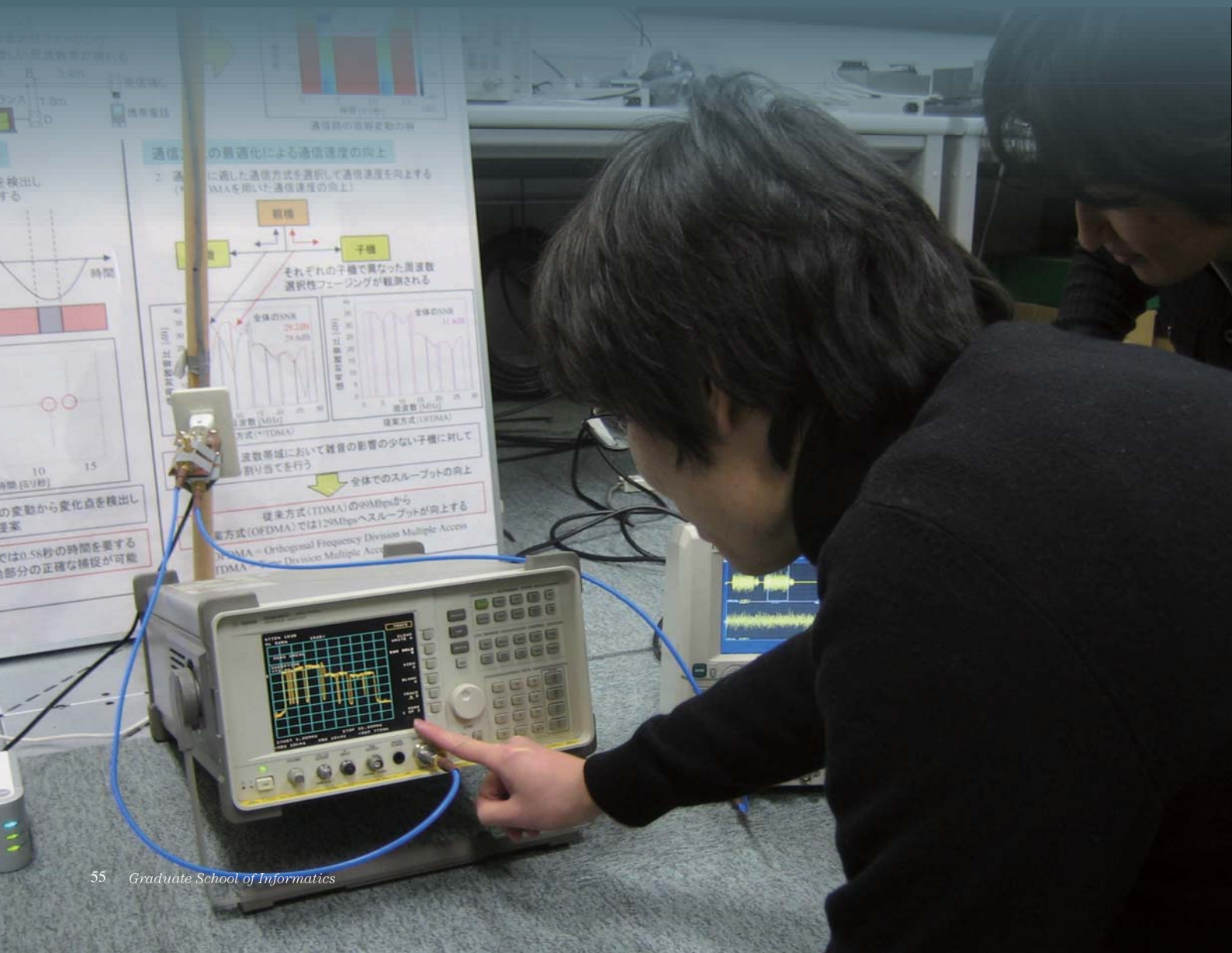



Supercomputer System in ACCMS

# Department of Communications and Computer Engineering

## *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 Department of Communications and Computer Engineering supports the development of future technologies in the fields of information processing devices and digital communications.



# *Shaping future information societies through VLSI design*

SATO Takashi, Department of Communications and Computer Engineering

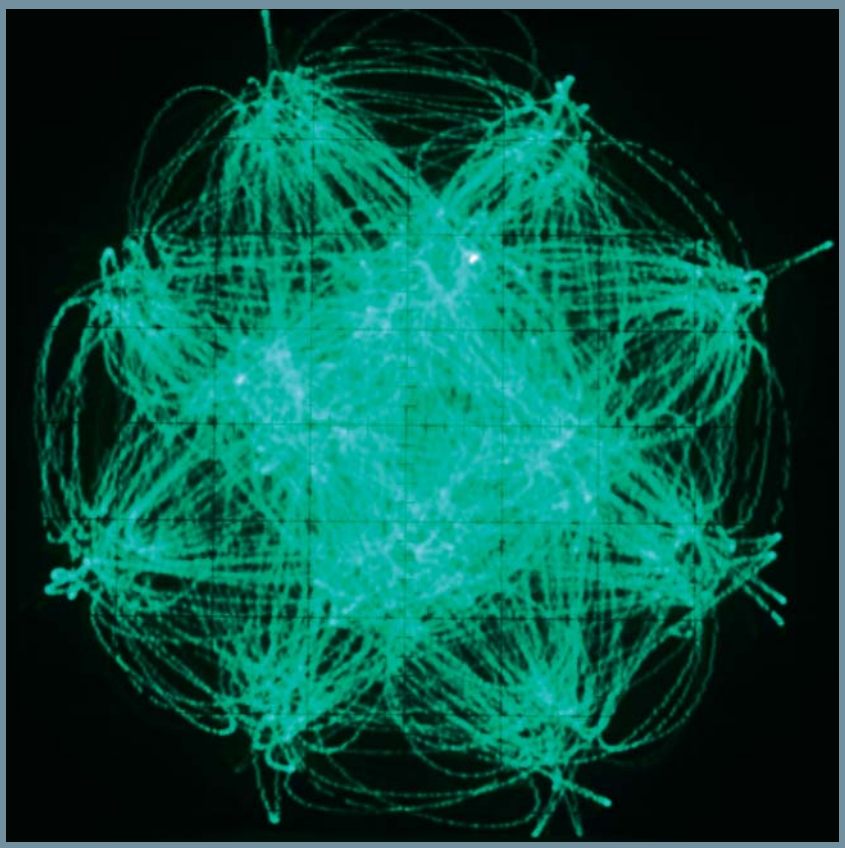
Very large-scale integration (VLSI) circuits and systems have been and will continue to play a key role in enhancing the safety and convenience of our everyday lives. An example is a sensor network system that translates various forms of information into electronic signals. Information on human behavior, health, natural environment, etc., will form an integral basis for building a future information society. To realize such systems, we have to solve for various problems that are important both academically and practically. In particular, we need to provide answers to the following questions. "How can we harvest energy from the environment to maintain long term data acquisition without batteries?" "How can we compress raw data to reduce communication energy?" "What is the theoretical lowest energy bound achievable in communications?" "How can we efficiently process massive amounts of information, gathered through a network connecting different types of sensors?"

In our group, we study fundamental technologies to realize energy-efficient VLSI systems through co-design of hardware and software. New ideas are promoted in discussions, analysis, simulation, and measurements through the collaborative work between students and faculties, whilst keeping practical applications in mind.

The Department of Communications and Computer Engineering focuses on education and research in areas such as future computer systems, communications, and integrated systems. Stimulating and broad topics ranging from academic research to cutting-edge industrial problems are waiting to challenge you.

# Department of Communications and Computer Engineering

## *Towards the Establishment of Fundamental Technologies in the Information Age*



## Divisions and Groups

| Division | Group | Research and Education Topics | Professor |
|---|---|---|---|
| Computer Engineering | Logic Circuits, Algorithms, and Complexity Theory | Logic Circuits, Algorithms, and Complexity Theory | IWAMA Kazuo |
| | Computer Architecture | Parallel Computing Mechanisms, Arithmetic Operation Circuits, and Hardware Algorithms | TAKAGI Naofumi |
| | Computer Software | Theory of Programs, Program Verification, Programming Languages | IGARASHI Atsushi |
| Communications Systems Engineering | Digital Communications | Highly Reliable and Secure Broadband Digital Communications Systems | HARADA Hiroshi |
| | Integrated-Media Communications | Integrated Transmission System and Applications | MORIKURA Masahiro |
| | Intelligent Communication Networks | Design and Performance Analysis of Highly Efficient Information Networks | TAKAHASHI Tatsuro |
| Integrated Systems] Engineering | Processor Architecture and Systems Synthesis | Large-scale, High-performance Information Circuit Architecture, and Design Technology | SATO Takashi |
| | Integrated Circuits Design Engineering | Design Technology of High Performance Large-scale Integrated Circuits | ONODERA Hidetoshi |
| | Advanced Signal Processing | High-speed and High-precision Digital Signal Processing Methods | SATO Toru |
| Radio Atmospheric Sciences(Affiliated) | Remoto Sensing Engineering | Atmospheric Measurement and Geophysical Environmental Information by Radio Waves, Light, and Acoustic Waves Using Electronic Engineering | YAMAMOTO Mamoru |
| | Atomospheric Observations | | TSUDA Toshitaka |
| Global 30 | Geometric Computation | Geometric Computation, Discrete Optimization, and Quantum Information | AVIS David |

## Graduate Curriculum

**Courses for the Master's Program**

Theory of Discrete Algorithms
Information Networks
Theory of Computational Complexity
Parallel and Distributed Systems
Formal Semantics of Computer Programs
Optical Communication Systems
Transmission Media Engineering (Advanced)
Integrated System Architecture and Synthesis
Atmospheric Measurement Techniques
Advanced Study in Communications and Computer Engineering I
Introduction to Algorithms and Informatics
Computational Intractability: NP-completeness and Integer Programming, with Scheduling Applications
Design in ICT
Digital Communications Engineering
Integrated Circuits Engineering (Advanced)
Parallel Computer Architecture
Digital Signal Processing (Advanced)
System-Level Design Methodology for SoCs
Remote Sensing Engineering
Advanced Study in Communications and Computer Engineering II
Hardware Algorithm

**Courses for the Doctoral Program**

Seminar on Computer Engineering, (Advanced)
Seminar on Communication Systems Engineering, (Advanced)
Seminar on Integrated Systems Engineering, (Advanced)
Seminar on Radio Atmospheric Science, (Advanced)
Seminar on Communications and Computer Engineering, (Advanced)

## Teaching Staff

**Professors**

IWAMA Kazuo; TAKAGI Naofumi; IGARASHI Atsushi; HARADA Hiroshi; MORIKURA Masahiro; TAKAHASHI Tatsuro; SATO Takashi; ONODERA Hidetoshi; SATO Toru; YAMAMOTO Mamoru (S); TSUDA Toshitaka (S); AVIS David

**Associate Professors**

TAKAGI Kazuyoshi; SUENAGA Kohei; MURATA Hidekazu; YAMAMOTO Koji; SHINKUMA Ryoichi; ISHIHARA Toru; NORIMATSU Seiji; HASHIGUCHI Hiroyuki (S)

**Assistant Professors**

TAMAKI Suguru; TAKASE Hideki; UMATANI Seiji; NISHIO Takayuki; HIROMOTO Masayuki; TSUCHIYA Akira; SAKAMOTO Takuya; YAMAMOTO Masayuki (S); FURUMOTO Jun-ichi (S); YABUKI Masanori (S); UENO Kenya; FUJII Keisuke; TAKI Hirofumi

(S) : Research Institute for Sustainable Humanosphere

# Computer Engineering

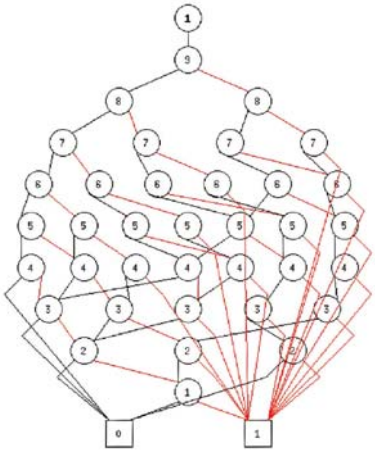
Enhancing the performance of computers is a clear challenge for the age of advanced information. Our goal is to respond to this challenge by conducting research and education on advanced technology for computer systems, including computer architectures for massively parallel information processing and fundamental software such as logic circuits, operating systems, and programming language systems.

## Logic Circuits, Algorithms and Complexity Theory

—The challenge of difficult computational problems—

Our main education and research theme is the design of algorithms for efficiently solving problems by computer. An algorithm is a procedure for solving problems automatically on computers. Arithmetic operations can be performed using logic circuits, or if it is a high-level operation, using a program. Computing the value of pi ( $\pi$ ) is a typical example in which computers perform well. On the other hand, scheduling problems, such as time schedules for schools or trains, are known to be computationally difficult problems for computers. We are meeting the challenge of such difficult computational problems from an algorithm engineering standpoint so as to enable computers to make increasingly significant contributions to society.

(Professor: IWAMA Kazuo, Assistant Professor: TAMAKI Suguru)

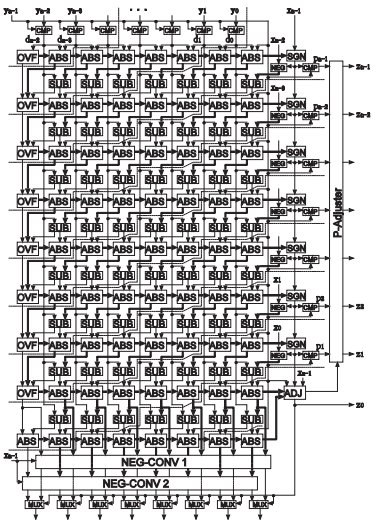


## Computer Architecture

—Achieving high-speed processing through parallel computing—

With the progress in integrated circuit technology, computers (processors) are being integrated as parts on circuit boards and LSIs, along with memories and various dedicated and peripheral circuits. We conduct education and research on new parallel computing mechanisms and arithmetic operation circuits that are suitable for integrated systems, hardware algorithms for dedicated circuits, and LSI system design technologies.

(Professor: TAKAGI Naofumi, Associate Professor: TAKAGI Kazuyoshi, Assistant Professor: TAKASE Hideki)



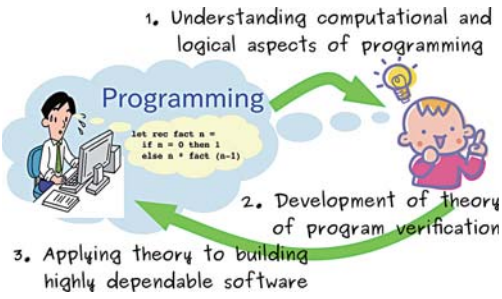

Block diagram for an integer divider based on a new hardware algorithm

## 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.

(Professor: IGARASHI Atsushi, Associate Professor: SUENAGA Kohei, Assistant Professor: UMATANI Seiji)



# Communications Systems Engineering

This division aims to conduct education and research on state-of-the-art technology with the goal of developing highly advanced information communication networks for handling multimedia information without network awareness. Topics include fundamental technologies for information communication networks such as the building of integrated wired and wireless digital information communication networks as well as adaptive digital signal processing and transmission technologies, information transmission media, network design and control technologies, and communication protocols that support them.

## Digital Communications

—Toward ubiquitous wireless information networks—

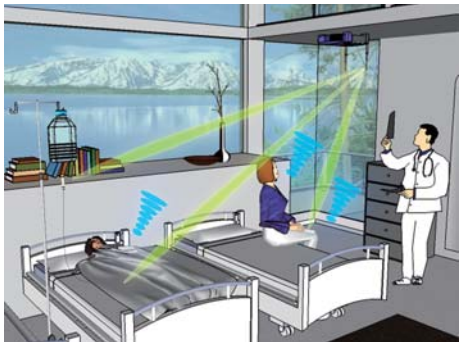
Wireless communication networks, accelerated by cellular radio together with short-range wireless communications and RFID tag technologies, for instance, have been advancing significantly towards the goal of so-called ubiquitous networks. That is, we are on the verge of an era when people can enjoy various 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.

(Professor: HARADA Hiroshi, Associate Professor: MURATA Hidekazu)

## Integrated-Media Communications

—Towards a unified wireless platform for an enormous number of terminals—

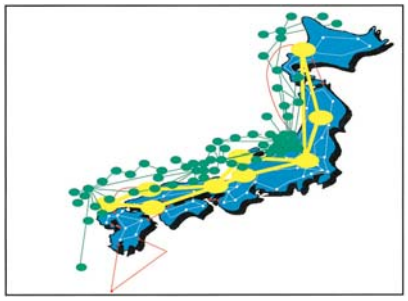


A key technology to realize smart metering for smart gird and vital monitoring for healthcare and medical care is machine-to-machine wireless networking. In the M2M wireless network, narrower bandwidth and longer communication distance are required compared to cellular networks and wireless LANs, and thus enormous number of terminals conflict with each other. In addition, batteryless terminals are required for maintenance-free. For those purposes, we research a unified wireless platform for the future society.

(Professor: MORIKURA Masahiro, Associate Professor: YAMAMOTO Koji, Assistant Professor: NISHIO Takayuki)

## Intelligent Communication Networks

—Towards highly intelligent information networks—



We study high-speed broadband backbone/access network architecture and network control and management technologies with the aim of developing enhanced information networks. Our education and research topics include optimal design technologies for network systems such as optical packet routers, ubiquitous mobile network control technology, QoS control, and management technologies that are indispensable to advanced applications, as well as wired and wireless seamless communications.

(Professor: TAKAHASHI Tatsuro, Associate Professor: SHINKUMA Ryoichi)

# Integrated Systems Engineering

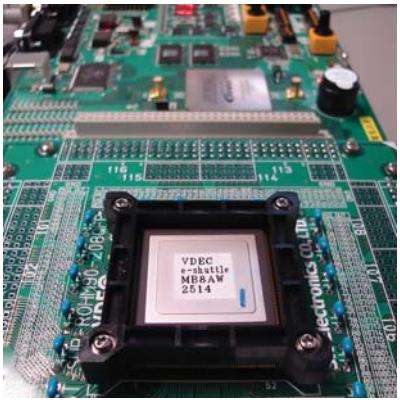
We conduct lectures and researches on high-performance, multifunctional, and highly-reliable large-scale integrated circuits and systems, which are fundamental infrastructures of future multimedia devices, computers, and communication systems. The research area includes processor architecture, algorithms for fast signal processing, massively parallel computing, and design methodologies for their circuit realization on advanced device technologies.

## 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.

(Professor: SATO Takashi, Assistant Professor: HIROMOTO Masayuki)




A reconfigurable LSI fabricated using 65nm process technology and its evaluation board

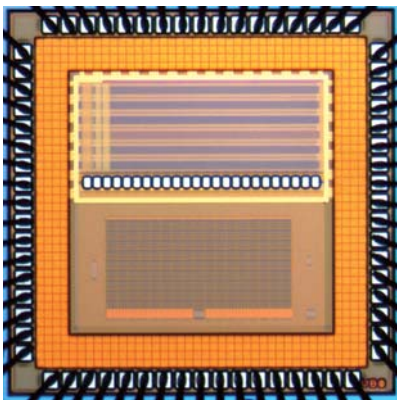
## Integrated Circuits Design Engineering

—Research on design methodology for advanced LSIs—

Integrated circuits are important devices that enhance functionality, improve performance, and reduce the cost of electronic systems. Since the integration of several devices in 1959, an integrated circuit today can accommodate more than one billion devices. With this rapid growth in circuit scale, how to configure and design circuits has become a key item of concern. Furthermore, as we enter the era of nanoscale integrated circuits, we are facing many challenging issues such as performance variability and reduced manufacturability.

This Group is conducting research and education regarding circuit configuration and design technologies for large scale integration and high miniaturization of LSIs; techniques for facilitating the production of highly manufacturable and reliable LSIs; and design methodology for high performance and energy-efficient embedded systems.

(Professor: ONODERA Hidetoshi, Associate Professor: ISHIHARA Tohru, Assistant Professor: TSUCHIYA Akira)



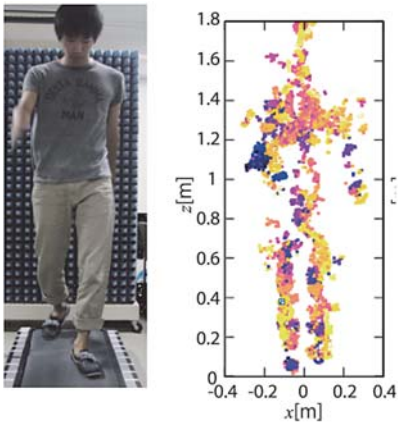
FPGA with built-in performance measurement capability

## Advanced Signal Processing

—Extracting the essence of the information in signals—

The definition of desired information to be extracted from signals is subjective and dependent on its application. It is thus necessary to thoroughly understand the essence of physical phenomena and mathematical formulations. We develop innovative signal processing algorithms through unique approaches by redefining the desired information to achieve significant performance improvements. Our research covers wide range of topics including ultra wide-band radar imaging, medical ultrasound systems and optical fiber communications.

(Professor: SATO Toru, Associate Professor: NORIMATSU Seiji, Assistant Professor: SAKAMOTO Takuya)



# Radio Atmospheric Sciences (Affiliated)

The Division of Radio Atmospheric Sciences conducts research and education regarding radio science, radio engineering, and information communication engineering related to the expansive atmospheric environment from the surface to the ionosphere. Our research focuses on the fields of applied radio engineering and information processing such as the development of different kinds of radar systems using sophisticated electronic circuit and computer technology, radar signal processing, radar observations of atmospheric waves, and remote-sensing systems.

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

## Remote Sensing Engineering

—Exploration of the Earth's atmosphere through radars—

The Indonesian equatorial region is the driving source of global atmospheric circulation, as well as phenomena such as the El Niño Southern Oscillation (ENSO) in the equatorial region, both of which influence weather in Japan. We have developed a VHF-band Equatorial Atmosphere Radar (EAR), and studied atmospheric phenomena in the equatorial region based on expertise acquired from our Middle and Upper-atmosphere (MU) radar observations. We have also developed a variety of radars for observing specific phenomena. Among such developed radars, the Japan Meteorological Agency adopted for its radar network (WINDAS) our small atmosphere radar specialized to observe the lower atmosphere (below 10 km). This network consists of 33 atmospheric radars and is used for weather forecasting. The scope of our research is not confined solely to the lower atmosphere, but also covers a wide area of the Earth's middle atmosphere (10-100 km) and the ionosphere (above 100 km).

(Professor: YAMAMOTO Mamoru, Associate Professor: HASHIGUCHI Hiroyuki, Assistant Professor: YAMAMOTO Masayuki)

## 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 development of atmospheric monitoring using radio waves of Global Positioning System (GPS) satellites and applications for weather forecasting, and profiling humidity — which was previously hard to monitor — by using radio-acoustic sounding and laser-radar techniques. We also carry out long-term 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. We also develop information systems for these studies.

(Professor: TSUDA Toshitaka, Assistant Professor: FURUMOTO Jun-ichi, Assistant Professor: YABUKI Masanori)

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

**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, psychology, and the arts (in cooperation with the Kyoto City University of Arts) 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 departments in the Graduate School of Informatics: Department of Intelligence Science and Technology, Department of Social Informatics, Department of Applied Mathematics and Physics, Department of Systems Science, and Department of Communications and Computer Engineering, 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 a Doctorate degree (Ph.D.).

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), and Graduate School of Informatics (Department of Intelligence Science and Technology, Department of Social Informatics, Department of Applied Mathematics and Physics, Department of Systems Science, and Department of Communications and Computer Engineering)

Partner Organizations:
Kyoto City University of Arts, NEC Corporation, Nippon Telegraph and Telephone Corporation (NTT), Nomura Research Institute, Panasonic Corporation, Mitsubishi Electric Corporation, Mori Building Co., Ltd., and about 40 members in Design Innovation Consortium (Osaka Gas Co., Ltd., OMRON Corporation, KDDI R&D Laboratories, Sharp Corporation, Sony Corporation, Toshiba Corporation, Nippon Telegraph and Telephone West Corporation (NTT WEST), IBM Japan, HAKUHODO Inc., Yokogawa Electric Corporation, Recruit Holdings Co., Ltd., etc.)

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

**International Course Program in Graduate School of Informatics**

Kyoto University was designated as one of the 13 hub universities for the "Project for Establishing Core Universities for Internationalization (Global 30)," which was launched in 2009 by the Ministry of Education, Culture, Sports, Science and Technology. In the initial phase of this project, participating universities were called upon to provide quality education according to their respective functions and to create an environment that makes it easier for foreign students to study in Japan. The G30 program was coordinated within Kyoto University and across all its participating graduate schools by the KU Profile Program.

As an ongoing result of the G30 initiative, we have simplified entrance procedures for foreign students and set up the International Course Program in the Departments of Intelligence Science and Technology, Social Informatics, and Communications and Computer Engineering of the Graduate School of Informatics. To be admitted in these departments, applicants can now take the entrance examination in English. Within those departments, a wide variety of courses are now taught in English. Thanks to this, students willing to acquire Kyoto University Master and Doctoral degrees can do so using only English. Note that the International Courses Program is open both to Japanese and foreign students, regardless of nationality.

International Courses website: http://www.g30.i.kyoto-u.ac.jp/

Contact: jyoho-kyomu@mail2.adm.t.kyoto-u.ac.jp (Student Affairs Division)

## Academic Programs

The Graduate School of Informatics provides graduate study programs that lead to Master's and Doctoral degrees. Taking into account the many different aspects of Informatics, students are required to take several compulsory credits outside their own department as a way to encourage interdepartmental education.

## Requirements for the Master's Program

To receive a Master's Degree, every student is required to take at least 30 credits, to submit a thesis in the student's field of specialization, and to pass an examination based on the thesis. To encourage a well-rounded curriculum of study, students are asked to take subjects offered not only by one's own department but by other departments as well.

## Requirements for the Doctoral Program

A Doctoral degree requires original, high-quality research in an individual field. To receive a Doctoral Degree, students are required to take at least 6 credits from courses offered at this school and to pass an examination based on the submitted thesis.

## The Number of Students to be Admitted by Department

| | Master's Program | Doctoral Program |
|---|---|---|
| Department of Intelligence Science and Technology | 37 | 15 |
| Department of Social Informatics | 36 | 14 |
| Department of Applied Analysis and Complex Dynamical Systems | 20 | 6 |
| Department of Applied Mathematics and Physics | 22 | 6 |
| Department of Systems Science | 32 | 8 |
| Department of Communications and Computer Engineering | 42 | 11 |
| Total | 189 | 60 |

Both non-Japanese and working professionals are eligible for admission into the graduate program. Doctoral students may enroll in this graduate school as part-time students concurrently with their professional responsibilities.

## Entrance Examination

The academic year begins in April and/or October. In general, a Master's degree requires two academic years of study, and a Ph.D. three years. Admission to graduate program is granted to those individuals who have passed the entrance examination of the Graduate School of Informatics conducted by the relevant departments. The examination is held from mid-July to mid-August. Additional examinations may be held in mid-December and mid-February in the event of vacancies.

Applications for the International Course, in which the degree will be earned in a solely English language medium, are also accepted in the departments of Intelligence Science and Technology; Social Informatics; Communications and Computer Engineering.

## For further information, please contact:

Graduate School of Informatics
Kyoto University
Yoshida-Honmachi, Sakyo-ku,
Kyoto 606-8501 JAPAN
Tel. +81 75-753-5038
http://www.i.kyoto-u.ac.jp

# 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.