2017

Kyoto University
Graduate School of Informatics

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Graduate School of Informatics

Graduate School

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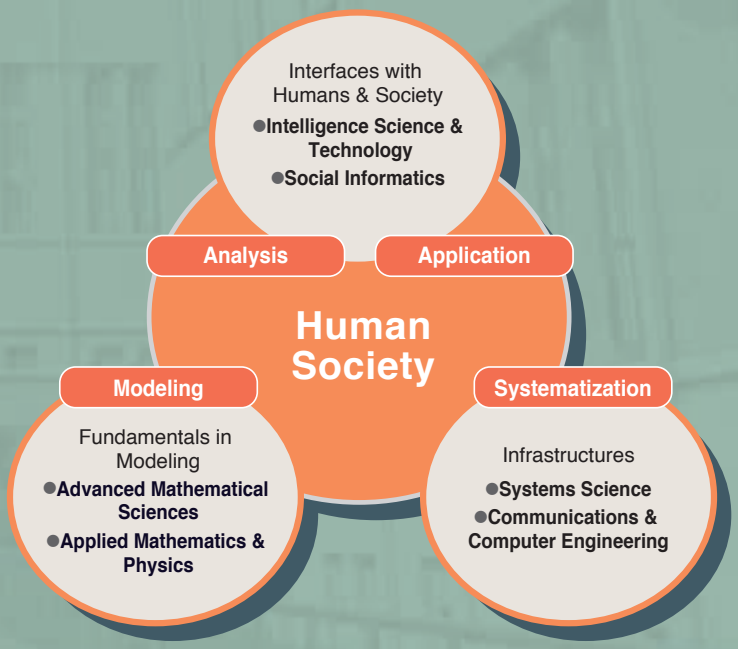
Outlines of the Graduate School of Informatics

Introduction of the Departments

Information

# of Informatics

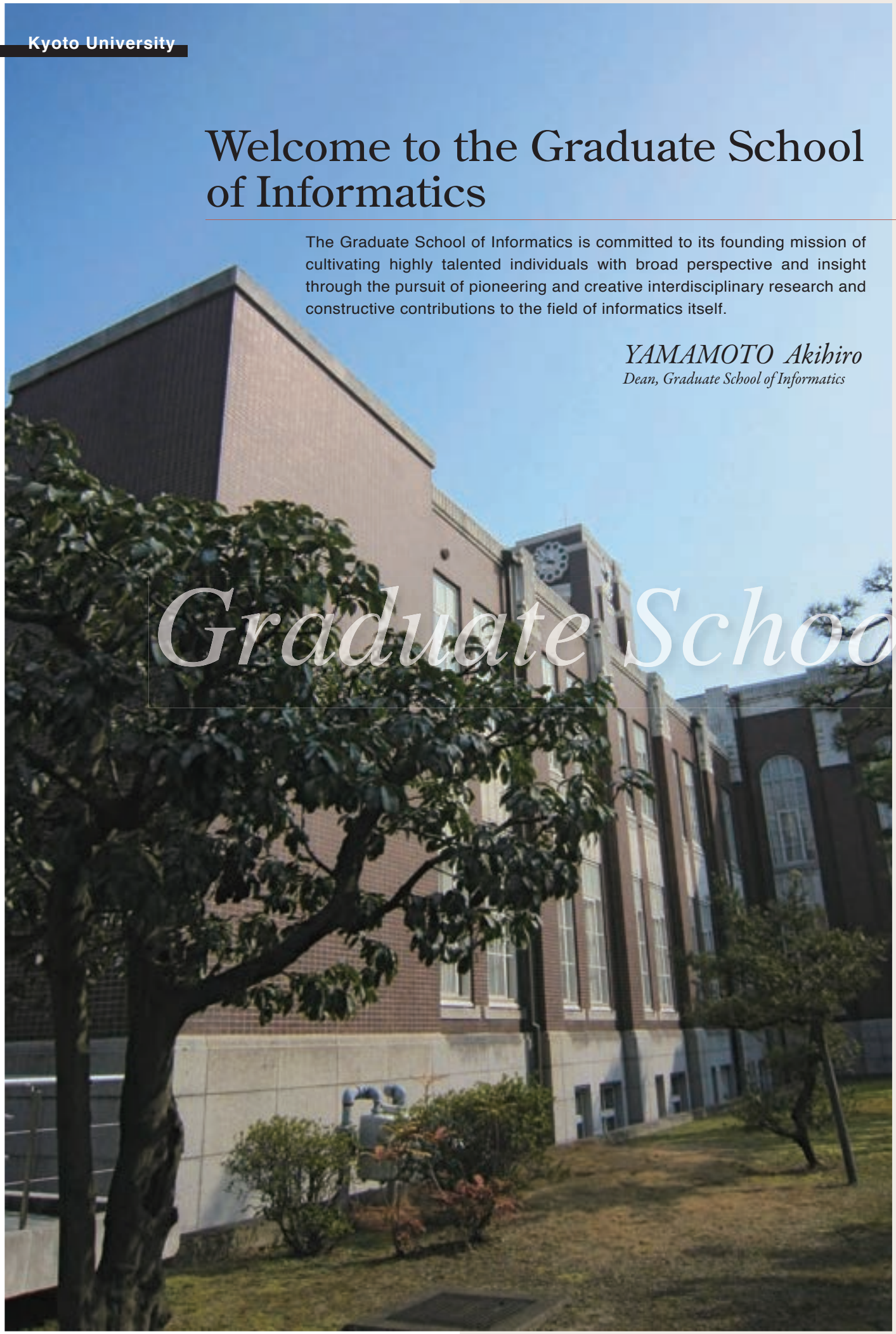
Informatics is a cutting-edge interdisciplinary field for the 21st century which assimilates information with humans and society.

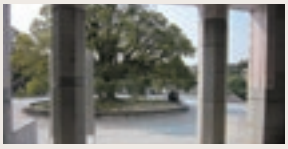


Welcome to the Graduate School of Informatics

The Graduate School of Informatics is committed to its founding mission of cultivating highly talented individuals with broad perspective and insight through the pursuit of pioneering and creative interdisciplinary research and constructive contributions to the field of informatics itself.

YAMAMOTO Akihiro
Dean, Graduate School of Informatics




a message of Informatics

Foreword

Computers and other information devices have become an integral part of daily life. We now live in an age in which people are more likely to read books or newspapers on a digital tablet than in the traditional formats on printed paper. With the spreading popularity of smartphones, the telephone has evolved into something much more than a device solely for the transmission of voice signals from afar. If you own a digital TV, you have access to a more diverse array of information content and are no longer limited to watching broadcast programs. If you have a smart card with integrated chip technology, you can use it for a wide range of electronic payments, including even bus or train fare. Should you run your own blog, microblog, or video server, you can easily broadcast your own content. And if you use social networking services, you have fresh opportunities to reconnect with old friends. Furthermore, the fusion of varied sensor technologies with information devices facilitates the accumulation of large volumes of data—so-called "big data"—that are harnessed for a range of social, academic, and corporate business activities. These activities in turn generate new data sets that are utilized by downstream activities, feeding a continuous process of development.

Informatics is an academic field that supports human activities of this nature in an increasingly advanced, knowledge-intensive world, and has itself evolved along the way. In this pamphlet for prospective students, I explain the academic discipline of informatics as well as the activities of the Graduate School of Informatics in education and research.

Informatics and the Graduate School of Informatics

In April 1998, Kyoto University created a new graduate school through the reorganization and integration of information-focused research at five faculties (Engineering, Science, Agriculture, Letters, and Integrated Human Studies). Because its scope encompassed such a broad diversity of academic fields, we decided to incorporate the term "informatics" into the name of this new school rather than use the established labels of "information engineering" or "information science." The Graduate School of Informatics is committed to its founding mission of cultivating highly talented individuals with broad perspective and insight through the pursuit of pioneering and creative interdisciplinary research and constructive contributions to the field of informatics itself.

Within the administrative context of academic endeavors in Japan, the academic name for the field of informatics first appeared in the List of Categories, Areas, Disciplines and Research Fields, which the Ministry of Education, Culture, Sports, Science and Technology (MEXT) prepared for its FY 2001 Grants-in-Aid Program for Scientific Research ("Kakenhi"). Initially, informatics was treated as one of several disciplines making up the area of multidisciplinary fields within the category of integrated and innovative sciences. However, in FY 2013, revisions to the list promoted informatics to a higher level within the hierarchy, assigning it status as one area in the integrated discipline category and comprising four disciplines and 21 research fields of its own. As revised, that list shows that "informatics" was recognized as a distinct academic area, squarely on an equal footing with the array of other areas in the category of science and engineering, which includes "engineering" and "medicine, dentistry, and pharmacy." What is more, the scope of academic research and education within the Kyoto University Graduate School of Informatics now spans more fields than the number of research fields shown under informatics in the revised list. Measured in terms of its sheer number of faculty members or students, the Graduate School of Informatics is currently the sixth-largest of the 15 graduate schools now operating at Kyoto University, and its activities encompass a broad spectrum of academic disciplines.

Research at the Graduate School of Informatics

The Graduate School of Informatics aims to fulfill a role as a center for international research in the informatics field and as a hub for community cooperation and collaborative ventures involving private industry and academia with the public sector. To this end, it has aided the creation and advancement of informatics as a new academic field and is determined to foster pioneering and creative academic research from an integrated perspective. The School was founded with a focus in three core areas of study: interfacing humans and society, mathematical modeling, and information systems. To translate this three-pronged focus into action, it launched six departments: Intelligence science and technology, Social informatics, Applied analysis and complex dynamical systems, Applied mathematics and physics, Systems science, and Communications and computer engineering. These departments now promote integrated research in collaboration with an array of other academic fields, including information processing, computer science, digital communications, applied mathematics, biology, cognitive psychology, control engineering, medicine, disaster prevention, environmental sciences, resources, and power generation and electrical engineering.

This pamphlet offers an overview of research activities underway within the Graduate School of Informatics. This graduate school handles over 10 large-scale research projects each year. In addition, among research fields in which Kyoto University is one of the top ten institutions as measured in terms of the number of projects approved for MEXT grants, the Graduate School of Informatics accounts for more than half of all new grant-subsidized projects in more than 10 research fields. These records effectively underscore its role of leadership in the field of informatics research. Indeed, research these days has in general shifted into an entirely new mode compared to the situation back when the School was founded. Some projects, for example, involve research on new applications for basic technologies but with a stronger emphasis on social value. In addition, research has not

been limited to themes centered on the internet or other information and communication technologies. We are also moving forward with projects to broadly apply research findings to, for example, the development of systems for implementation and use in hospital settings and the development of instrumentation to monitor conditions in polar environments. The School has also been energetically involved in collaborative research with private companies, and in many cases the outcomes have been commercialized or led to the development of new products. In FY 2013, the School set up a new laboratory in collaborative research, which has fostered pioneering research in collaboration with four private companies.

The high energy level displayed by its younger researchers is one of the School's defining hallmarks. Many research projects are being led by young researchers. Additionally, many doctoral students have been selected as research fellows under the Research Fellowships for Young Scientists Program of the Japan Society for the Promotion of Science, thus getting off to a strong start as leaders of the next generation in informatics research.

Education at the Graduate School of Informatics

Education at the Graduate School of Informatics is focused on training highly qualified engineers and cultivating researchers that will be able to excel within the new academic field of informatics. To help achieve this mission, the School welcomes aspiring students not only from the fields of informatics, electronics, or electrical engineering—divisions and departments with a direct connection to ICT—but also those from a broad range of additional backgrounds, regardless of whether they have a scientific or humanities-based orientation. It also accepts numerous exchange students from abroad and has prepared courses that can be completed without prerequisite Japanese language proficiency, as detailed later. The Doctoral program, moreover, enthusiastically accepts—as professional students—individuals who have completed a master's degree and are continuing with careers as researchers at private companies or research institutes.

Students that complete the School's degree programs pursue active careers in a vast range of fields. In addition to filling research positions in universities or corporate research institutes, they also excel as high-level engineers in areas ranging from information and communications technology and manufacturing, to broadcasting, and services.

The Master's program provides a carefully crafted curriculum of education, which combines a vertical fabric of the six departments' specialized education with a horizontal fabric of common and advanced courses based on varied education projects as well as education and training projects that involve cooperation with private industry. The specialized education curriculum treats each of the six departments as an independent unit and links diverse areas of research together with the major themes of each department. This educational scope has been further enhanced through the creation of cooperative lecture courses with on-campus research institutes and collaborative units with corporate research houses.

Research activities are an inseparable component of education at the graduate school level, in both Master's and Doctoral programs. Immediately after enrolling, students take a course in research guidance and begin preparing to write their dissertation papers. While enrolled, most students—even those in the Master's program—will eventually submit a thesis after gaining experience with giving paper presentations and delivering conference presentations in Japan and abroad. The energy level of student research typically reflects the many awards and commendations that students receive through conferences and other venues in response to their research findings.

The Graduate School of Informatics has been pushing strongly to boost its level of international diversity. Including program-specific faculty positions, the School currently has 11 foreign faculty members, and it offers multiple courses that are taught directly by foreign researchers engaged in the most advanced research as the Interdisciplinary Courses of Perspective on Informatics. Additionally, three departments provide international courses, with many of the courses taught in English. This makes for an environment that allows foreign exchange students to acquire credit without Japanese language mastery and encourages Japanese students to strengthen their awareness of diversity and work with and learn from foreign peers.

Among new education projects, in FY 2012, MEXT launched its Program for Leading Graduate Schools. The Graduate School of Informatics began participating in the Inter-Graduate School Program for Sustainable Development and Survivable Societies that same year, and in FY 2013 it launched the Kyoto University Collaborative Graduate Program in Design. All are degree programs that were created to tie together graduate school Master's and Doctoral programs, equip qualified students with powers of insight and creativity, and prepare such students for roles as future leaders on the global stage in a broad array of industrial, academic, and public-sector careers. It is anticipated that the study of design in particular will evolve as an academic field forming core foundational technologies for future society, and the Graduate School of Informatics has taken the initiative to help foster this trend. In focusing so much energy on the training of specialists, traditional doctoral degree education programs have drawn criticism for producing sheltered environments and individuals that lack flexibility. Given this image, we are striving to cultivate "+ shaped" ("plus-shaped") people—individuals that can couple advanced expertise with the broad perspectives that give them the power to design social systems and architectures. To achieve this goal, the Graduate School of Informatics has teamed up with an array of world-leading companies to present real problems to people on the front lines of the development



enterprise and has put emphasis on developing group-led solutions through field-based learning (FBL) and problem-based learning (PBL). Additionally, through collaboration with universities abroad, it has established international internships in corporate workplaces in other nations. On this basis, it aims to cultivate global-scale perspectives.

In FY 2009, the Graduate School of Informatics created an affiliated Center for Promotion of Informatics Education, which in FY 2014 it renamed to Unit for Promotion of Informatics Education. This Center is aimed at students enrolled in not only the Graduate School of Informatics but other faculty and graduate schools as well. It has the purpose of promoting the study, formulation, and implementation of university-wide informatics education programs that will facilitate the cultivation of human resources with knowledge of information science, computer science, information-intensive social systems, and business, as well as the ability to contribute to the pool of human innovation. Graduate-level interdisciplinary courses have been integrated into the curriculum for students at the Graduate School of Informatics as well.

To Students Interested in a Career in Informatics

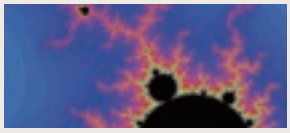
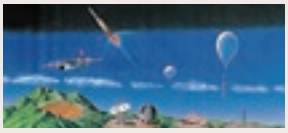
Informatics is a comprehensive academic field. Specialists in informatics are prepared to make contributions in many areas of academic endeavor and to society at large. To foster effective and efficient research and development work on technologies aimed at aiding responses to and solutions for an array of problems confronting Japan and the wider international community, the 4th Science and Technology Basic Plan currently advocated by the Japanese government cites a need for research and development work on technologies that can be applied in multiple fields. As a specific initiative, it has been proposed that research and development be encouraged in the fields of simulation, e-science, and other forms of advanced ICT as well as mathematical science, systems science technology, and other interdisciplinary technologies that can be utilized in multiple fields. These fields fall precisely within the scope of informatics.

In closing, I want to point out that whenever the accomplishments of informatics are applied to new fields of endeavor, the benefits are not necessarily limited to progress in such fields alone. Frequently, these efforts provide a new perspective that in return enables the field of informatics itself to expand and grow. Achieving growth through that process will demand that students learn independently and interactively, as stated in Kyoto University's mission statement, firmly assimilate the latest informatics accomplishments, and master necessary skills for the pursuit of research. The Graduate School of Informatics is committed to creating foundations of support for the international society of the future, and it welcomes each and every individual that aspires to aid the advancement of informatics as a young researcher.

YAMAMOTO Akihiro
Dean, Graduate School of Informatics

Professor Yamamoto obtained his B.S. degree from Kyoto University in 1985. In 1990, he completed Kyushu University's Information Systems course for a Doctor of Science degree. Hokkaido University appointed him to the position of lecturer in the Department of Electrical Engineering in 1990, to associate professor in the same department in 1994, and to associate professor in the Division of Electronics and Information Engineering of its Graduate School in 1997. In 2003, he was appointed to his current position as professor in the department of Intelligence Science and Technology of the Graduate School of Informatics at Kyoto University.
(In the interim, Professor Yamamoto also spent one year abroad in 1996 as a Ministry-of-Education-sponsored visiting researcher at the Technical University of Darmstadt in Germany. In 1998, he began a three-year stint as a researcher on the theme, "Information and Human Activity" under the Precursory Research for Embryonic Science and Technology [PRESTO] 21, a Japan Science and Technology Agency initiative).

Graduate School


Departments

Division	Group			
Department of Intelligence Science and Technology				**P.09**
Brain and Cognitive Sciences	Neuroinformatics	Psychoinformatics	Cognitive Communication	Computational Cognitive Neuroscience (Adjunct Unit)
Cognitive System	Computational Intelligence	Collective Intelligence	Conversational Informatics	
Intelligent media informatics	Language Media Processing	Speech and Audio Processing	Visual Information Processing	
Application of Multimedia (Affiliated)	Video Media	Network Media	Media Archiving Research	
Bio-system Informatics (Affiliated)	Biological Information Networks			
Cooperative Intelligence (Joint Research Chair)	Cooperative Intelligence			
Department of Social Informatics				**P.19**
Social Information Model	Distributed Information Systems	Digital Library	Information Society (Adjunct Unit)	
Social Information Network	Global Information Network	Information Security (Adjunct Unit)	Market and Organizational Information Systems (Adjunct Unit)	
Biosphere Informatics	Bioresource Informatics	Environmental Informatics		
Regional and Disaster Management Information Systems (Affiliated)	Integrated Disaster Management Systems	Emergency Management for Disaster Reduction Systems	Crisis Information Management System	
Medical Informatics (Affiliated)				
Information Fluency Education (Affiliated)				
Department of Advanced Mathematical Sciences				**P.29**
Applied Analysis	Applied Analysis			
Nonlinear Physics	Nonlinear Physics			
Applied Mathematical Sciences	Computational Mechanics	Industrial Mathematics		
Department of Applied Mathematics and Physics				**P.35**
Applied Mathematics	Applied Mathematical Analysis	Discrete Mathematics		
Applied Mathematical Systems	System Optimization	Control Systems Theory	Applied Mathematical Modeling (Adjunct Unit)	
Mathematical Physics	Physical Statistics	Dynamical Systems		
Mathematical Finance (Affiliated)				
Department of Systems Science				**P.41**
Human Machine Symbiosis	Mechanical Systems Control	Human Systems	Integrated Dynamical Systems	
Systems Synthesis	Adaptive Systems Theory	Mathematical System Theory	Computational Intelligence Systems (Adjunct Unit)	
Systems Informatics	Information Systems	Integrated Systems Biology	Biomedical Engineering	Computational Neuroscience (Adjunct Unit)
Applied Informatics (Affiliated)				
Department of Communications and Computer Engineering				**P.49**
Computer Engineering	Logic Circuits, Algorithms and Complexity Theory	Computer Architecture	Computer Software	
Communications Systems Engineering	Digital Communications	Integrated-Media Communications	Intelligent Communication Networks	
Integrated Systems Engineering	Processor Architecture and Systems Synthesis	Integrated Circuits Design Engineering	Advanced Signal Processing	
Radio Atmospheric Sciences (Affiliated)	Remote Sensing Engineering	Atmospheric Observations		

of Informatics

Department of Intelligence Science and Technology

Department of Intelligence Science and Technology

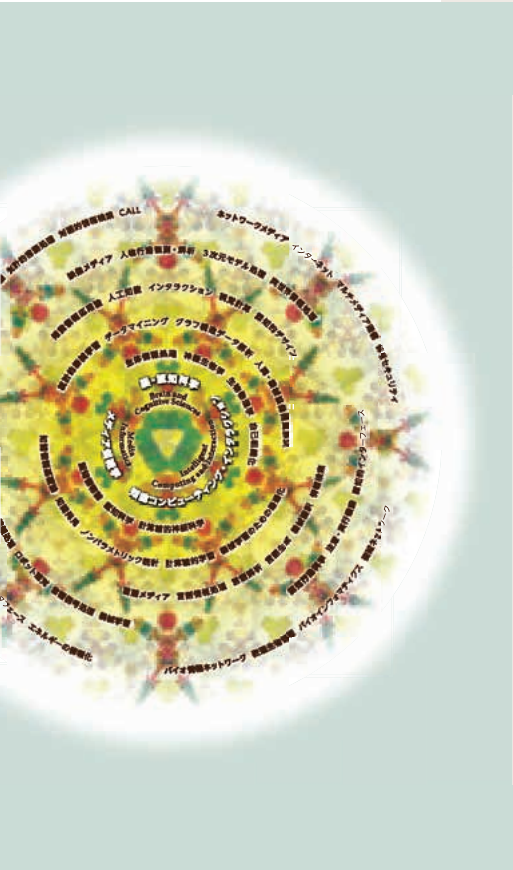
Construction and Elucidation of Intelligence Realization of Flexible, Human-like Information Processing.

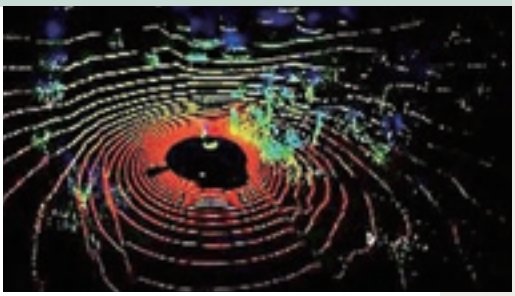
In an advanced information-oriented society, we require information processing with flexible, human-like information capabilities.

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.





Welcome to Department of Intelligence Science and Technology

Intelligence Science and Technology is an interdisciplinary research field in which we study sophisticated human information processing and develop new technologies on the basis of an understanding of human intelligence. By “intelligence,” we do not mean simply “`artificial intelligence” but rather a wider scope embracing intelligent aspects of human, systems, and information technology. More specifically, our research and educational activities include (i) basic mechanisms of human beings, such as life, brain, cognition, and behavior, (ii) information media related to language, speech/auditory, and visual information, and (iii) a broad range of topics related to intelligence and informatics, such as interaction between human and intelligent systems, artificial intelligence and machine learning, and software and networks. One of our distinguishing features is integration of these topics under a unique discipline, “intelligence science and technology,” notwithstanding that these topics are also investigated in separate research fields such as neuroscience, psychology, engineering, and computer science. Faculty members and students coming from a wide variety of academic backgrounds devote themselves to cooperating in pursuit of this common goal. We hope that, in this unique academic environment, many young students will engage in this exciting research field, tackle the mysteries of complex human intelligence, and develop new ideas for addressing challenging issues regarding intelligent media and computation.

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

KASHIMA Hisashi
Professor, Department of Intelligence Science and Technology

1999 M.S., Applied System Science, Kyoto University.
1999 Researcher, IBM Research - Tokyo.
2007 Ph.D., Intelligence Science and Technology, Kyoto University.
2009 Associate Professor, The University of Tokyo.
2014 Professor, Kyoto University.

Department of Intelligence Science and Technology

Outline

Divisions and Groups

Division	Group	Research and Education Topics	Professor
Brain and Cognitive Sciences	Neuroinformatics	Operating Principles of the Nervous System and the Brain and Basic Principles of Information Processing	KAMITANI Yukiyasu
	Psychoinformatics	Human Attention and Executive Function, and Cognitive Interface	KUMADA Takatsune
	Cognitive Communication	Neural Mechanism of Communication	
	Computational Cognitive Neuroscience (Adjunct Unit)	Neural Information Processing and Computational Models	NAKAHARA Hiroyuki
Cognitive System	Computational Intelligence	Information Modeling for Intelligent Information Processing Mechanism	YAMAMOTO Akihiro
	Collective Intelligence	Machine Learning and Data Mining	KASHIMA Hisashi
	Conversational Informatics	Understanding and Designing Interaction, Human Computer Interaction Using Visual Information	NISHIDA Toyoaki
Intelligent Media Informatics	Language Media Processing	Natural Language Processing, Knowledge Engineering	KUROHASHI Sadao
	Speech and Audio Processing	Recognition and understanding of speech, audio and music	KAWAHARA Tatsuya
	Visual Information Processing	Image Recognition and Understanding	
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	MORI Shinsuke
Bio-system Informatics (Affiliated)	Biological Information Networks	Bioinformatics, Computational Systems Biology	AKUTSU Tatsuya
Cooperative Intelligence (Joint Research Chair)	Cooperative Intelligence	Cooperative Intelligence	KUMADA Takatsune

Graduate Curriculum

Courses for the Master's Program

Introduction to Cognitive Science
Introduction to Information Science
Introduction to Bioinformatics
Seminar on Cognitive Science
Computational Cognitive Neuroscience
Computational Learning Theory
Pattern Recognition (Advanced)
Conversational Informatics
Multimedia Communication
Speech Processing (Advanced)
Language Information Processing (Advanced)
Computer Vision
Visual Interface
Statistical Learning Theory
Bioinformatics (Advanced)
Seminar on Intelligence Science and Technology I, II, III, IV
Advanced Study in Intelligence Science and Technology I
Advanced Study in Intelligence Science and Technology II

Courses for the Doctoral Program

Seminar on Intelligence Science and Technology, Advanced
Seminar on Brain and Cognitive Sciences, Advanced
Seminar on Cognitive System, Advanced
Seminar on Intelligence Media, Advanced
Seminar on Application of Multimedia, Advanced
Seminar on Bio-system Informatics, Advanced

Teaching Staff

(M) : Academic Center for Computing and Media Studies

Professors

KAMITANI Yukiyasu; KUMADA Takatsune; NAKAHARA Hiroyuki (RIKEN, Adjunct); YAMAMOTO Akihiro; KASHIMA Hisashi; NISHIDA Toyoaki; KUROHASHI Sadao; KAWAHARA Tatsuya; MINOH Michihiko (M); OKABE Yasuo (M); MORI Shinsuke (M); AKUTSU Tatsuya (Institute for Chemical Research)

Associate Professors

LIANG Xuefeng; NAKAZAWA Atsuhi; KAWAHARA Daisuke; KAWASHIMA Hiroaki; IIYAMA Masaaki (M); MIYAZAKI Shuichi (M); SHIMAZAKI Hideaki; FUNAKOSHI Kotaro

Senior Lecturers

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

Assistant Professors

MAEGAWA Shingo; MAJIMA Kei; ICHINOSE Natsuhiro; KOBAYASHI Yasuaki; BABA Yukino; YOSHINAKA Ryo; OHMOTO Yoshimasa; MURAWAKI Yugo; ITOYAMA Katsutoshi; KOTANI Daisuke (M); TAMURA Takeyuki (Institute for Chemical Research)

Brain and Cognitive Sciences

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.

Neuroinformatics

Decoding neural codes

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

[Professor: KAMITANI Yukiyasu,
Senior Lecturer: HOSOKAWA Hiroshi,
Assistant Professor: MAEGAWA Shingo,
Assistant Professor: Kei Majima]

Psychoinformatics

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

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

[Professor: KUMADA Takatsune,
Assistant professor: ICHINOSE Natsuhiro]

An experiment examining eye and action coordination

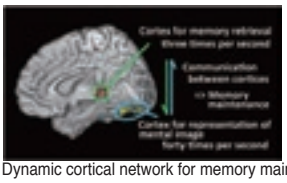
Cognitive communication

Towards a systematic understanding of the human brain

In order to obtain a systematic understanding of the human brain, we engage in both experimental and theoretical research and education on how higher human cognitive functions operate. Specifically, we conduct studies that entail both psychological experiments and functional brain imaging to investigate how higher-level functions -- such as verbal and nonverbal communication, multi-modal integration, and mnemonic function -- are carried out in the brain. We are also developing new methods for brain imaging techniques to help us understand the mechanisms of human brain functioning.

[Senior Lecturer: MIZUHARA Hiroaki]

Please look at this upside-down.



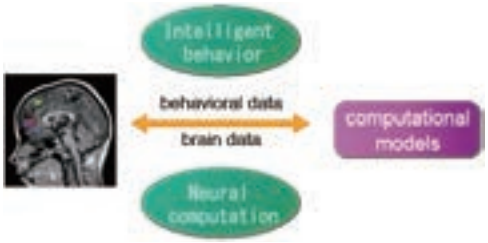
Dynamic cortical network for memory maintenance.

Outline

Computational cognitive neuroscience (Adjunct unit)

Neural information processing and computational models

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



Cognitive system

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.

Computational intelligence

Formulation of principles to support intelligent information processing

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

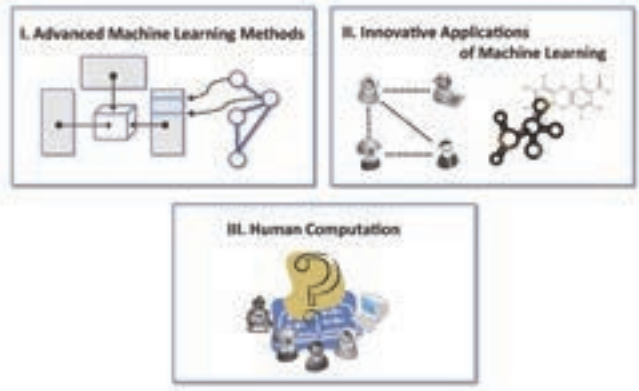
[Professor: YAMAMOTO Akihiro,
Assistant Professor: KOBAYASHI Yasuaki]

Collective intelligence

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: BABA Yukino]



Conversational Informatics

Design and understanding of social intelligence and interaction

People converse with each other for many reasons: to exchange information, to discuss an issue, to resolve a conflict, to increase mutual understanding, to compose a joint story, or just for fun. Conversation will remain as a vital means for people to communicate with other people and autonomous agents in the emerging human-agent symbiotic society. Our group centers on understanding and augmenting conversational interactions. We are keen to provoke and support empathic conversation in which participants are engaged in a game-like activity to make tacit thoughts explicit and organize them into a larger discourse in a very effective trial-and-error fashion. Building and management of common ground consisting of a shared knowledge and belief among participants is a key issue to make it happen. We take a data-intensive approach to acquire and utilize data entailing how participants interact with each other, what information to be shared, and which aspects of the environment are relevant. We aim at building a computational framework for sharing and cultivating wisdom through enhancing conversational interactions and facilitating conversational content in a community. The primary theoretical backbone is conversation quantization that characterizes conversation as a series of conversational quanta, each of which packages information about relevant participants, references to the objects and events discussed in the discourse, a series of verbal and nonverbal utterances exchanged by the participants, commitments to previous discourse (themes), and new propositions in the discourse (rhemes). We focus on smart conversation space, conversation capture, conversation production, cognitive approach, and synthetic evidential study.

[Professor: NISHIDA Toyoaki,
Associate Professor: NAKAZAWA Atsushi,
Assisitant Professor: OHMOTO Yoshimasa]

Outline

Intelligent media informatics

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.

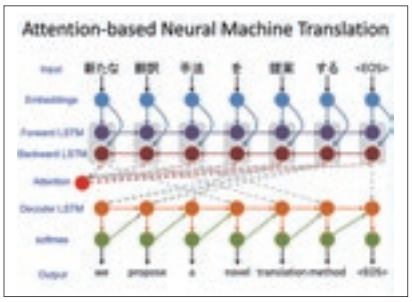
—Development of Search Engine Infrastructure based on Deep Natural Language Processing—

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,
Assistant Professor: MURAWAKI Yugo]

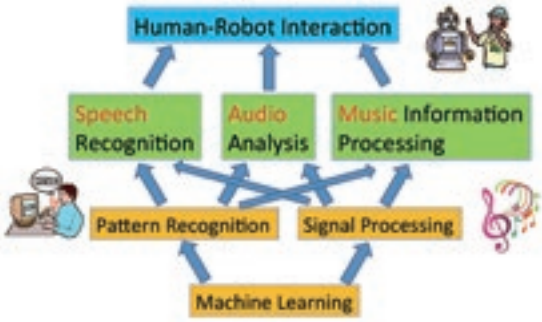


Speech and Audio Processing

Recognition and understanding of speech, audio and music

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

[Professor: Tatsuya Kawahara
Senior Lecturer: Kazuyoshi Yoshii
Assistant Professor: Katsutoshi Itoyama]



Visual Information Processing

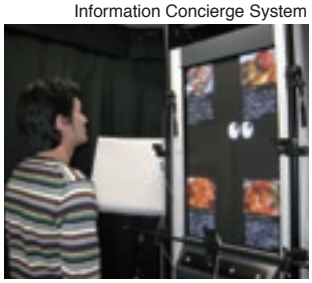
Towards systems that understand visual information

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 and translucent microscale objects as is, and a multimodal interaction system for understanding human intent/meaning behind human behavior to realize suitable information guidance and conversation.

[Associate Professor: KAWASHIMA Hiroaki,
Senior Lecturer: NOBUHARA Shohei]

3D video technology

Information Concierge System



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-centric artificial intelligence environment through video media

Computers act as "information media" to support human activities and communication. Understanding human activities and recognizing the environments in which humans function are necessary for developing such information media.

We study intelligent information technologies for human-centric AI environments and apply them to various fields, such as education, tourism, culinary activities, and primary industries.

- Understanding student behavior for an adaptive education system.
- Smart kitchen system that understands and supports culinary activities.
- Tourist behavior and attribute recognition for recommending optimal activities in light of urban congestion.
- Global-scale environmental data processing for supporting people in primary industries.

[Professor: MINOH Michihiko, Associate Professor: IIYAMA Masaaki]

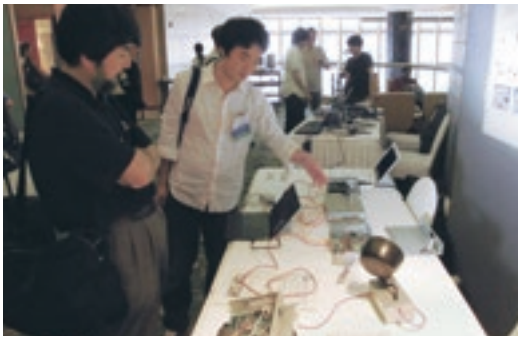
Outline

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. To that end, we are working on fundamental research issues pertaining to the next-generation Internet, including IPv6 architecture and programmable networks, operation technologies such as automatic network configurations, platform technologies that support various services, such as identity federation, and security. We are also working on technologies for integration of information, communication through application of Internet protocols and algorithms such as routing, matching, reservation and interruption, and power management. We also work on design and analysis of algorithms for combinatorial optimization problems, and on proving the intractability of problems.

[Professor: OKABE Yasuo,
Associate Professor: MIYAZAKI Shuichi,
Assistant Professor:KOTANI Daisuke]



Demonstration of on-demand power network

Media Archiving Research

Speech and Natural Language Processing for Multi-media Archives

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

Specifically, we deal with real-world media, including procedural texts such as cooking recipes with execution videos, academic knowledge such as history/geography research, and game/data analysis by computers.
We also try to expand human knowledge based on our research results.

[Professor: MORI Shinsuke]

Bio-system Informatics (Affiliated)

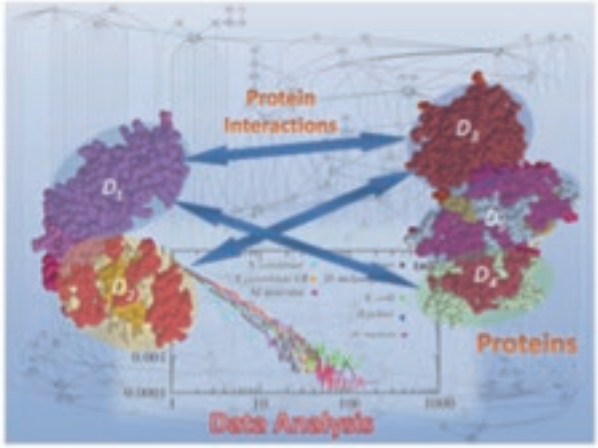
Biological systems and creatures are ineffably complex systems in which many kinds of chemical structures, proteins, genes and other objects interact with one another. We examine these as interactive networks to implement education and research aimed at elucidating and understanding the system, mainly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



Analysis of three-dimensional structures and interactions of protein

Cooperative Intelligence (Joint Research Chair)

In the near future, artificial intelligence will drastically change interpersonal relationships, or the involvement of humans in society. This joint research chair is aimed at establishing a new concept of “cooperative intelligence” toward a society in which humans and intellectual systems can coexist, and it investigates new technologies for realizing the concept. We are also seeking to develop a new form of open innovation under this joint research framework.

Department of Social Informatics

Harmonizing Society and Information Technology

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

Information is Born in the Lives of People

Sources of social information do not exist on the Internet. These sources are usually found in people's daily lives. Social informatics includes processes from the acquisition of information from the sources, through constructing systems to utilize the information, to designing a better society using those information systems. For example, we collect ecological information relevant to fish by using bio-logging techniques for fishery resource conservation. We also glean biological information from forest ecosystems using various types of sensors to optimize the sustainable utilization of ecosystem services. Then, we study methods for database development to organize that information on natural resources and environments. Moreover, we study informatics applications in the fields of medical services and education, and also determine what types of information are needed for disaster prevention and harm minimization. We consider ways to utilize the data to design societies and social systems. We, the people in the Department of Social Informatics, work to acquire data directly related to our lives and societies, and to reformulate and store it in the most accessible and useful way to enable the development of our sustainable future.

OHTE Nobuhito
Department of Social Informatics

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

Fundamental Studies of Informatics and its Social Deployment

Information technologies are expected to become a driving force for dramatic change in many established social systems. Students in the Department of Social Informatics will understand both the possibilities and limitations of information technologies by mastering its basics. This understanding will also enable students to learn the social deployment of information technologies. Faculty members of the department include researchers in information technologies, and domain experts in biology, agriculture, medicine, disaster-prevention, and education. A variety of educational opportunities are provided to students, including the acclaimed advisor system. The educational goal of our department is to produce quality graduates who can resolve social problems or design new social systems by utilizing information technologies. In our department, many research topics are being studied even in laboratories oriented towards computer science. These include computer-supported clinical decision making, route recommendations for pedestrians that uses vital signs and confluent route search, estimation of the credibility of Web contents, and collective decision making. If you are interested in mastering information technologies and thereby creating a better society, you are strongly invited to join us.

YOSHIKAWA Masatoshi
Department of Social Informatics

Masatoshi Yoshikawa received B.E., M.E. and Ph.D. degrees from Department of Information Science, Kyoto University in 1980, 1982 and 1985, respectively. He was on the faculty of Kyoto Sangyo University, Nara Institute of Science and Technology (NAIST) and Nagoya University before he joined Department of Social Informatics, Kyoto University in 2006. His general research interests are in fundamental studies of data science and its social deployment. He is a past editor of The VLDB Journal and Information Systems.

Outline

Divisions and Groups

Division	Group	Research and Education Topics	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	
	Information Society (Adjunct Unit)	Management of Intellectual Property and Associated Information	TANIGAWA Hidekazu MIYAWAKI Masaharu
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	OHTE Nobuhito
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	HATAYAMA Michinori
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	OGATA Hiroaki

Graduate Curriculum

Courses for the Master's Program

Social Informatics
Information System Design
Information System Analysis
Practice of Information Systems
Dispersed Information Systems
Information Organization and Retrieval
Multi-Agent Systems
Biosphere Informatics
Disaster and Information
Crisis Management
Medical Informatics
Business Information
Information Education
Cryptography and Information Society
Advanced Study in Social Informatics 1
Advanced Study in Social Informatics 2
Theories of Service Modeling

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

((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

Teaching Staff

Professors

YOSHIKAWA Masatoshi; TAJIMA Keishi (Institute of Liberal Arts and Sciences, Secondary); TANIGAWA Hidekazu (Adjunct); MIYAWAKI Masaharu (Adjunct); ISHIDA Toru; OKAMOTO Tatsuaki (NTT, Adjunct); YOKOZAWA Makoto (Nomura Research Institute, Adjunct); MORIYA Kazuyuki; OHTE Nobuhito; TATANO Hirokazu (D, Affiliated); YAMORI Katsuya (D, Affiliated); HATAYAMA Michinori (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; JATOWT Adam; YAMADA Atsushi (ASTEM, Adjunct); MATSUBARA Shigeo; ABE Masayuki (NTT, Adjunct); KINOSHITA Takashi (Nomura Research Institute, Adjunct); MITAMURA Hiromichi; KOYAMA Lina; SAMADDAR Subhajyoti (D, Affiliated); ONISHI Masamitsu (D, Affiliated); UEDA Hiroshi (M, Affiliated); TAMURA Hiroshi (H, Affiliated)

Senior Lecturers

OKAMOTO Kazuya (H, Affilated)

Assistant Professors

SHIMIZU Toshiyuki; YAMAMOTO Takehiro; KATO Makoto; LIN Donghui; NISHIZAWA Hideaki; VINCENOT Christian; HIRAGI Shusuke (H, Affiliated)

Social Information Model

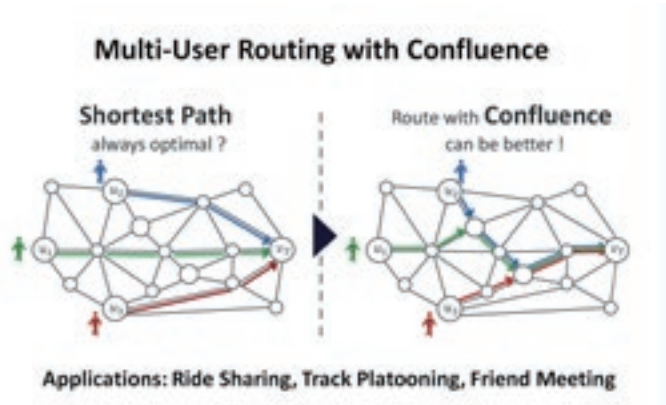
The development of information networks has enabled the widespread use of information bases distributed throughout the world. The Social Information Model Division's Groups are based around a discussion of the formation of these distributed information bases. Through a study of the creation of working 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

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 evolution of a) technologies to enable the rapid and accurate transmission of data; and b) technologies to allow rapid searches of vast volumes of data to retrieve required information in a timely manner. For this reason, we conduct fundamental research on data mining, geographic information systems, Web information systems, social network analysis, and privacy protection. We also carry out application-oriented research such as health/medical big data analysis, scientific data management, integrated utilization of knowledge bases and search engines, utilization of scholarly data, educational information systems, in cooperation with domain experts.

[Professor: YOSHIKAWA Masatoshi,
Associate Professors: MA Qiang, ASANO Yasuhito, JATOWT Adam,
Assistant Professor: SHIMIZU Toshiyuki, KATO Makoto]

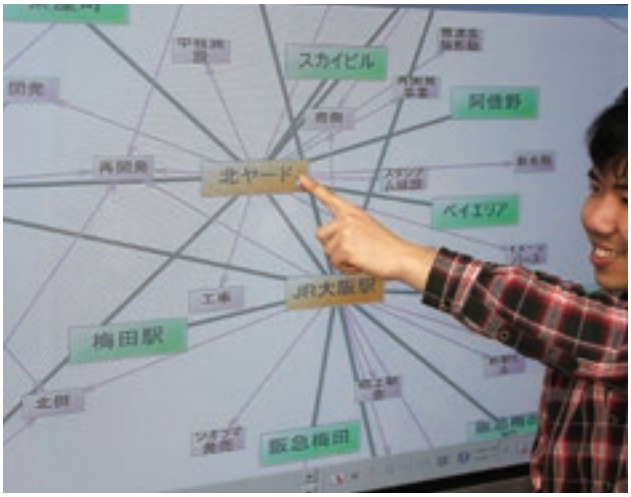


Digital Library

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.

[Assistant Professor:YAMAMOTO Takahiro]



Outline

Social Information Network

Information networks enable us to communicate by various means, regardless of spatial or temporal constraints, and influence the structure of our society. The use of these information networks will create new social information systems and contribute to social change on a global scale. The Social Information Network Division consists of the Global Information Network Group, the Information Security Adjunct Unit, and the Market and Organizational Information Systems Adjunct Unit.

Global Information Network

Seeking global collaboration

This Group aims to generate advanced technologies for Internet-based worldwide collaboration. Based on artificial intelligence and a human interface, we conduct global research activities with researchers in the US, Europe and Asia to build real-world systems while addressing the latest technological issues including services computing, Internet of Things (IoT), crowdsourcing, incentive design, and auctions. We also work closely with the Kyoto University Design School to promote practical education such as shaping and solving problems in the real world.

[Professor: ISHIDA Toru,
Associate Professor: MATSUBARA Shigeo,
Assistant Professor: LIN Donghui]

Multilingual Communication Support for Youths using the Language Grid

Column

From the World to Japan, from Japan to the World

Over 40 foreign students are enrolled in the Department of Social Informatics, representing more than 15 countries. You may obtain a sense of global community by studying in such a diverse environment. Many students from the Department of Social Informatics make presentations, discuss research, and join internship programs abroad.

A welcome party is held in October to welcome newcomers from foreign countries, and various kinds of international exchanges happen on a daily basis.

Research presentation at an international conference (Canada)

An international event

Biosphere Informatics

There is a great variety of organisms in the biosphere, for example in environments such as forests, farmlands or seas. These organisms have complex interrelationships, and influence our society in various ways. Our division attempts to comprehensively understand the information about individual animals as well as bioresources and production by using various methods and techniques to gather data about the biosphere. We also study the influence of human activities on the global environment and human society itself through the production and management of bioresources and ecosystems.

Bioresource Informatics

Seeking utilization and conservation of bioresources

This group discusses and studies a wide range of themes including system evaluation 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 bioresource data, this group works in the development and application of new research methods involving the use of GPS, biotelemetry, biologging and image analysis.

[Professor: MORIYA Kazuyuki,
Associate Professor: MITAMURA Hiromichi,
Assistant Professor: NISHIZAWA Hideaki]



Various methods and techniques are applied

Environmental Informatics

Seeking conservation and utilization of ecosystems

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

[Professor: OHTE Nobuhito,
Associate Professor: KOYAMA Lina,
Assistant Professor: VINCENOT Christian]



Fieldwork is conducted in various types of sites

Outline

Regional and Disaster Management Information Systems (Affiliated)

Disasters are abrupt and large-scale environmental changes. The natural, artificial and social environments (and especially the balance among them) that have been constructed and maintained by regional communities are forced to change. If the impact of a disaster is sufficiently severe, local communities may be unable to recover the balance that they had before the catastrophe, and may be forced to create a new balance. This was demonstrated in 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 disastrous events. 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) enhancing our ability to foresee and predict threats; (2) improving our ability to limit the degree of damage; 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 some $US440 billion in damage. Population growth is driving urbanization. Societies are becoming more complex and diverse. Meanwhile, disasters are growing in scale and occurring more frequently. It could be said 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 establishment of information systems designed to achieve "urban disaster reduction" that both minimizes the immediate effects of disasters and shortens aftermath duration.

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: Subhajyoti SAMADDAR]

Flood Risk Communication Support System

Emergency Management for Disaster Reduction Systems

Social scientific research for disaster damage reduction

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

[Professor: YAMORI Katsuya,
Associate Professor: ONISHI Masamitsu]

Disaster education materials developed in our lab

Crisis Information Management System

Disaster Information Systems with Information Technology

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

[Professor: HATAYAMA Michinori]

Development of Building Damage Certification System considering Operator's Ability in the Great East Japan Earthquake

Medical Informatics (Affiliated)

Illustrating the future of clinical medicine in the information age

Although nobody performs any modern clinical medical activity without computational support, the current clinical system is still poorly adapted to the information revolution. The Medical Informatics Laboratory tries to illustrate the future of clinical medicine in the information age through research aimed to implement information platforms for, to analyze clinical information of, and to provide feasible information support for existing clinical entities, 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, Electronic Health Record (EHR)), Data Health (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, Health Tourism).

[Professor: KURODA Tomohiro,
Associate Professor: TAMURA Hiroshi,
Senior Lecturer: OKAMOTO Kazuya
Assistant Professor: HIRAGI Shusuke]

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: OGATA Hiroaki,
Associate Professor: UEDA Hiroshi]

Outline

Adjunct Units

Information Society Adjunct Unit

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

The application of IT to social systems

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 "Π-type" people who are familiar with the systems and processes of not just 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: YOSHIKAWA Masatoshi, TANIGAWA Hidekazu and MIYAWAKI Masaharu, Associate Professor: YAMADA Atsushi]

Information Security Adjunct Unit

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

In today's world, where the Internet is increasingly used to conduct electronic transactions such as electronic settlements and bidding in online auctions, or to carry out functions required by the government, such as the filing of tax returns, the maintenance of 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 and develop various applied cryptographic technologies commonly used today such as public key cryptosystems, crypto currency, electronic voting, and other applications suitable for cloud computing with rigorous security analysis based on a firm theoretical foundation.

[Professors: OKAMOTO Tatsuaki and ISHIDA Toru, Associate Professor: ABE Masayuki]

Information Security Adjunct Unit
—Creating a safe networked society through cryptography—
(in collaboration with NTT Corporation)

Market and Organizational Information Systems Adjunct Unit

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

Informatics is changing our society. Everything in our life and business is based on data and networking, and global flows of products are rapidly being replaced by flows of data and services. In this unit, we focus our research on these areas: 1. Analysis of socioeconomic mechanisms in the digital economy and society, 2. Scientific design of new businesses, 3. Study of public policies regarding dependable management and operation of the Internet, and 4. Research on personal data protection for secure and reliable digital business. These studies are based on collaborative research and experiments with a private think-tank, governments, international organizations, industry associations, ICT companies, local communities, and virtual communities.

[Professors: YOKOZAWA Makoto and ISHIDA Toru, Associate Professor: KINOSHITA Takashi]

Special Education Program of the Department of Social Informatics

1. Specialized Subjects and Special Lecture


Special lecture

In the first year of the Master's program, students are introduced to specialized subjects including the design and analysis of information systems, and the relationship between information and society. They can acquire the fundamentals of informatics from the ground up through these subjects, and even students with less specific experience in informatics can benefit by combining their informatics and other expertise. In addition, we have more than 50 special lectures a year in our department, for which we invite lecturers from various universities, research institutes and government offices.

2. Education for innovation


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

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

3. Education for globalization


Strategic communication seminar

The Department of Social Informatics and Berlitz worked together to develop teaching materials that have been used in a "strategic communication seminar" provided by the Kyoto University Design School. Students in the Department of Social Informatics can benefit from the focused English lecture presented by lecturers from Berlitz.

Department of Advanced Mathematical Sciences

Mathematical Modeling and Analysis of Phenomena

— In Pursuit of Integration of Science and Engineering —

The essence of science is to derive principles from observations, thereby revealing the simple structures that underlie what appear to be complex phenomena.

Mathematical sciences, in particular, use mathematical approaches to investigate "mathematical models", which are derived through experimentation.

The modern frontier of mathematical sciences considers various new mathematical models, including those for biological and social phenomena, in addition to more traditional models in natural sciences. These models are investigated through analytical approaches as well as numerical simulations in order to understand the phenomena.

The knowledge thus obtained is employed to develop innovative technologies or to predict future developments, and new methodologies are devised for deeper understanding of phenomena.

In its research and educational activities, our department pays particular attention to large-scale and/or highly non-linear complex phenomena.

Particularly in education, we aim at providing students with both scientific perspectives, which help them to understand principles, and engineering perspectives which are useful in solving real problems in manufacturing.

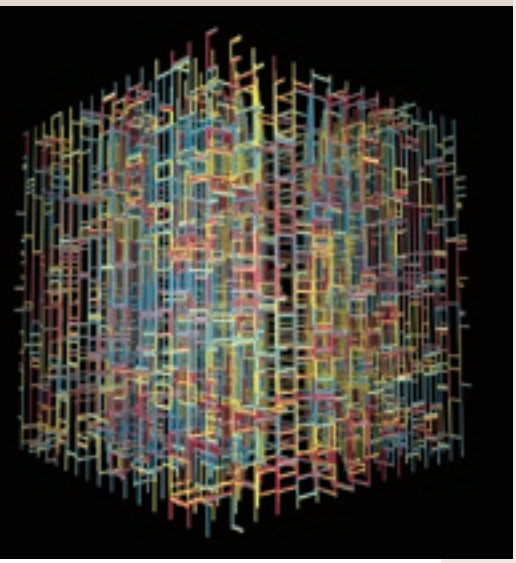
This two-pronged approach gives students comprehensive overviews on both science and engineering in mathematical sciences.

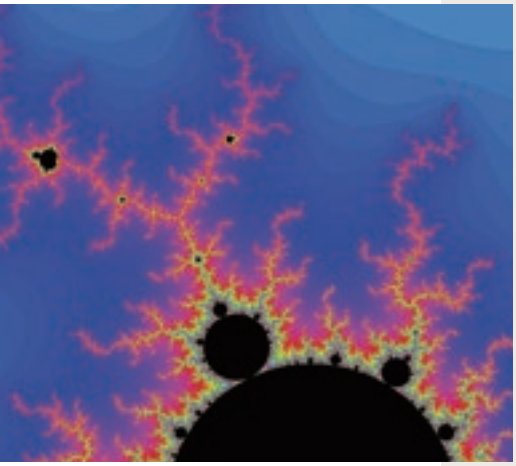
An Invitation to Mathematical Sciences

In the Graduate School of Informatics, we regard "mathematical modeling and analysis of natural, social and biological phenomena" as an important foundation of what we aim at; i.e., "informatics" in the broad sense of the term, which includes not only traditional computer science but also related disciplines such as mathematical sciences, applied physics, etc. Indeed, we have placed importance on research and education in mathematical sciences since the establishment of our school in 1998 because they are considered to form the academic basis of our disciplines. At the time of inauguration of the school, we considered it appropriate to name ourselves the "Department of Applied Analysis and Complex Dynamical Systems", since "complex dynamical systems" was the phrase that symbolized the advanced mathematical sciences of the time. However, the relentless advancement of mathematical sciences gradually made "complex dynamical systems" not necessarily the best phrase to express what we are. Meanwhile, development of computers and networks has made it possible to deal more easily with so-called “big data,” thus making computers and networks increasingly important in social life as well as in research and education in mathematical modeling and analysis of natural, social and biological phenomena. With these developments in mind, we have decided to change the name of our department to "Department of Advanced Mathematical Sciences," as of April 2017. We believe that the new name reaffirms and clarifies our directions for both education and research.

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

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





NISHIMURA Naoshi
Department of
Advanced Mathematical Sciences

1979: M.Eng. (civil engineering), Kyoto Univ., 1988: Dr. Eng. (civil engineering), Kyoto Univ., 1979-1996: Faculty of Engineering, Kyoto University, 1996-2002: raduate School of Engineering, Kyoto University, 2002-2006: Academic Center for Media Studies, Kyoto Univ., 2006: Professor, Graduate School of Informatics, Kyoto University. Research area: Computational Mechanics, Applied Mechanics, Computational Electromagnetics.

Outline

Divisions and Groups

Division	Group	Research and Education Topics	Professor
Applied Analysis	Applied Analysis	Inverse and Ill-Posed Problems, Fractal Theory, Nonlinear Differential Equations, Numerical Analysis, Probability	ISO Yuusuke KIGAMI Jun
Nonlinear Physics	Nonlinear Physics	Theoretical Neuroscience, Network Science, Nonequilibrium or Nonlinear Physics, and Computational Condensed Matter Theory	AOYAGI Toshio
Applied Mathematical Sciences	Computational Mechanics	Computational Mechanics	NISHIMURA Naoshi
	Industrial Mathematics	Kinetic theory, Fluid Mechanics	

Graduate Curriculum

Courses for the Master's Program

Applied Analysis A
Applied Analysis B
Nonlinear Physics A
Nonlinear Physics 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 Physics A
Topics in Nonequilibrium Physics B
Seminar in Nonlinear Physics I
Seminar in Nonlinear Physics II
Topics in Nonlinear Physics I
Topics in Nonlinear Physics II
Topics in Computational Mechanics A
Topics in Computational Mechanics B
Topics in Mathematical Sciences A
Topics in Mathematical Sciences 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 Mathematical Sciences I
Advanced Study in Mathematical Sciences II

Courses for the Doctoral Program

Seminar on Mathematical Sciences (Advanced)
Seminar on Applied Analysis (Advanced A & B)
Seminar on Nonlinear Physics (Advanced A & B)
Seminar on Applied Mathematical Sciences (Advanced A & B)

Teaching Staff

Professors
ISO Yuusuke; KIGAMI Jun;
NISHIMURA Naoshi;
AOYAGI Toshio

Associate Professors
FUJIWARA Hiroshi;
YOSHIKAWA Hitoshi;
TAGUCHI Satoshi

Senior Lecturers
KUBO Masayoshi;
MIYAZAKI Syuji;
SHIRAISHI Daisuke;
CHEN I-kun

Assistant Professors
TUTU Hiroki;
HARADA Kenji;
NIINO Kazuki

Admission, Curriculum and Other Efforts in Our Department

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

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

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

Applied Analysis

Applied mathematics seeks to go far beyond mere application of pure mathematics to 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 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

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

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

■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.
[Professor: KIGAMI Jun]

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

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

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

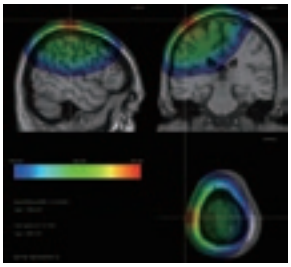
I mathematically analyze partial differential equations that appear in mathematical physics and mathematically and numerically analyze the inverse problems found in these partial differential equations, where the unknown coefficients of these inverse problems are determined by observed data.
[Senior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

■Structure of Brownian Motion and Random Walk

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

■Boltzmann Equations, Kinetic Models

I am interested in the Boltzmann equations, kinetic models, and related inverse problems.
[Senior Lecturer: CHEN I-kun]



Numerical Simulation of Light Propagation in a Human Brain (top) and Hardware used in Simulation (bottom).

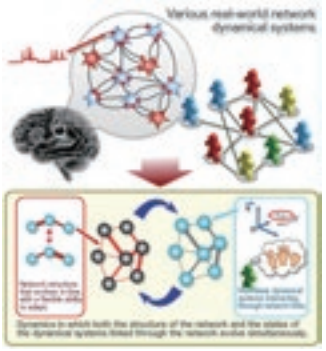
Outline

Nonlinear Physics

The dynamic behavior of systems that have a high degree of freedom and engage in nonlinear mutual interactions is both complex and richly diverse; nevertheless, many of these systems share common characteristics, e.g., exhibiting coherent structures, and are fascinating subjects for research. In our sub-department, we use theoretical analysis and computer simulations to gain a better understanding of the complex behaviors and control of these types of dynamic systems and to clarify their universal principles. Our research covers topics in dynamical systems that range from nonlinear and nonequilibrium physics to theories of networks appearing in living and social systems; moreover, our staff members constantly interacts with each other while teaching and conducting research on these subjects.

■From nonlinear and nonequilibrium physics to the theory of networks and its application to 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. From more general 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 investigates 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. [Professor: AOYAGI Toshio]



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.

■Nonequilibrium nonlinear physics, complex networks

I study characteristic temporal fluctuations in the vicinity of variou bifurcation points of a chaotic-dynamical system based on the statistical thermodynamic formalism, and I have a keen interest in applications of the projection-operator method used in statistical physics to perform effective calculations of temporal correlations as well as thermodynamic functions. I consider a variety of natural and social phenomena as a complex network from a unified standpoint. I promote cooperation with high schools, and strive to stir young people's interest in natural science by illustrating the abovementioned research fields. [Senior Lecturer: MIYAZAKI Syuji]

Double pendula showing chaotic motion:
Starting from almost identical initial conditions as shown in the upper figure, we observe quite different time evolution, as shown in the lower figure; thus, we say that the system has a sensitive dependence upon initial conditions.

■Mathematical models for molecular machines from the perspective of nonequilibrium physics

Biological molecular motors are amazing machines that generate useful movement (as a pump or a porter). The relationship between the structures of proteins and their highly efficient energy conversion, even under a fluctuating environment, remains mysterious. Our group explores the underlying principles of such molecular machines with models based on stochastic differential equations from the perspective of nonequilibrium physics.
[Assistant Professor: TUTU Hiroki]

■Computational condensed matter theory

The new exotic thing emerges even from simple elements and rules. Even if we know them in detail, it is a very difficult, but fascinating task to predict the total property of the system. Base on the computational approach, I focus on such problem. For example, critical phenomena in a quantum matter at zero temperature and nonequilibrium steady state in the autonomous system. [Assistant Professor: HARADA Kenji]

Applied Mathematical Sciences

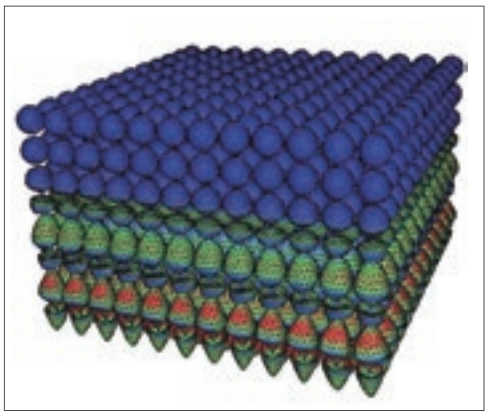
Many of objects that we study in mechanics are large and complex, and often exhibit behavior that is uncertain and difficult to predict. Although the most important issue for us is to accurately predict this behavior and control it, this is generally not easy to do. It is essential to establish sophisticated mathematical models of physical systems and to develop high-speed and accurate simulation techniques to analyse them. Numerical simulation techniques are particularly important in nano-scale and/or global phenomena where experimental approaches are extremely difficult. This division investigates mathematical modeling and simulation techniques and their applications from the viewpoints of applied mathematical sciences.

Computational Mechanics

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

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

[Professor: NISHIMURA Naoshi,
Associate Professor: YOSHIKAWA Hitoshi,
Assistant Professor: NIINO Kazuki]

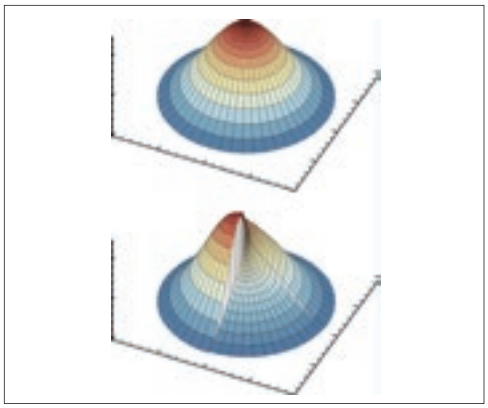


Example of analysis using a time domain fast multipole boundary integral equation method

Industrial Mathematics

Toward new fluid mechanics for non-equilibrium flows

Our main research interest is to clarify the behavior of non-equilibrium gas flows and to establish theories to describe them. Through theoretical and/or computational approaches applied to kinetic equations, describing the statistical behavior of many particles, we elaborate new continuum theories applicable to non-equilibrium flows. We also derive and construct related mathematical models for non-equilibrium flows and clarify the relations between various fluid models. [Associate Professor: TAGUCHI Satoshi]

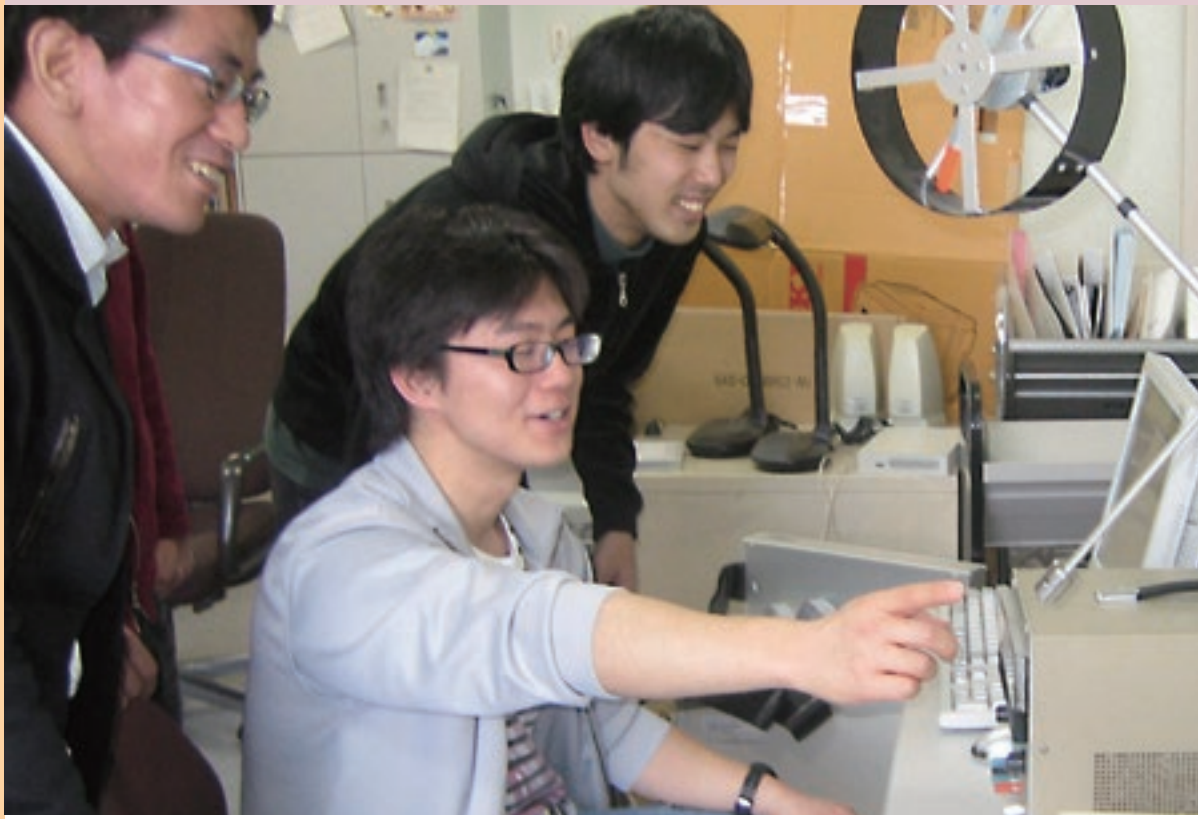


Example of velocity distribution function of gas molecules. Local equilibrium state (top) and locally non-equilibrium state (bottom). The conventional continuum theory is applicable only to the situation where the local equilibrium is satisfied everywhere in the fluid. We develop and elaborate a new framework of fluid mechanics applicable to a wider class of flows, including non-equilibrium flows.

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 uncover common mathematical structures shared by those problems which are seemingly unrelated, and to develop mathematical methods to solve them, in addition to acquiring specialized knowledge of individual disciplines such as information technology, electricity, mechanics and chemistry.
From this viewpoint, the 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

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.

OHTA Yoshito
Department of Applied Mathematics and Physics

Professor Ohta graduated from the Department of Electronic Engineering, School of Engineering, Osaka University in 1980. He was appointed as a Research Associate in Osaka University in 1983, and obtained his Doctorate Degree in Engineering from Osaka University in 1986. He was promoted to a Lecturer in 1991, to an Associate Professor in 1994, and to a Professor in 1999 at Osaka University. Since 2006, he is a Professor at the Department of Applied Mathematics and Physics at Kyoto University.

Optimization of Discrete Structures

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.

NAGAMOCHI Hiroshi
Department of Applied Mathematics and Physics

Professor Nagamochi received his Doctorate degree in March 1988 from the Graduate School of Engineering, Kyoto University. In April 1988 he was appointed a Research Associate at the Informatics Division, Toyohashi Institute of Technology. In April 1990 he became a Research Associate at the Section of Applied Mathematics and Physics, School of Engineering, Kyoto University, and in April 1993 promoted to Associate Professor. In April 2000 he returned to the Informatics Division of Toyohashi's Institute of Technology as a Professor. As of July 2004 he is a Professor at the Graduate School of Informatics, Kyoto University. His research specialty is discrete optimization, covering a broad range of fields which include, among others, graph algorithms, scheduling, and enumeration algorithms.

Outline

Divisions and Groups

Division	Group	Research and Education Topics	Professor
Applied Mathematics	Applied Mathematical Analysis	Applied Integrable Systems and Numerical Algorithms	NAKAMURA Yoshimasa
Applied Mathematical Systems	Discrete Mathematics	Theory and Application of Discrete Optimization, Graph Theory, and Discrete Algorithms	NAGAMOCHI Hiroshi
	System Optimization	Optimization Theory & Algorithms and Operations Research	YAMASHITA Nobuo
	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
	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)
Mathematical Physics (Advanced)
Systems Analysis (Advanced)
Topics in Applied Mathematics and Physics A, B
Mathematical Analysis (Advanced)
Discrete Mathematics (Advanced)
Control Systems Theory (Advanced)
Optimization Theory (Advanced)
Physical Statistics (Advanced)
Introduction to Mathematical Finance
Financial Engineering
Dynamical Systems (Advanced)
Advanced Study in Applied Mathematics and Physics I
Advanced Study in Applied Mathematics and Physics II

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; YAMASHITA Nobuo; OHTA Yoshito;
YAMAMOTO Akira (Hitachi, Ltd.,Adjunct); UMENO Ken; YAGASAKI Kazuyuki

Associate Professors

TSUJIMOTO Satoshi; KIMURA Kinji (Program-Specific Associate Professor); KASHIMA Kenji;
SATO Tatsuhiro (Hitachi, Ltd., Adjunct); IGARASHI Akito; SHIBAYAMA Mitsuru

Assistant Professors

KAMIOKA Shuhei; SEKIDO Hiroto (Program-Specific Assistant Professor); SHURBEVSKI Aleksandar;
FUKUDA Ellen Hidemi; OHKI Kentaro; 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 combinatorial problems, graph and network problems, logical functions, discrete optimization, and other topics. The Applied Mathematics Division conducts research and education 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.

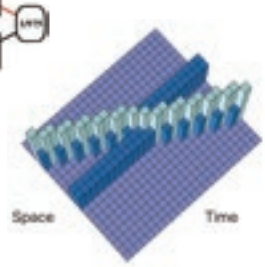
Applied Mathematical Analysis

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]

η-algorithm
(discrete KdV equation)



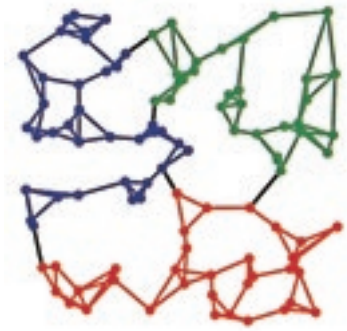
Ultra-discrete soliton

Discrete Mathematics

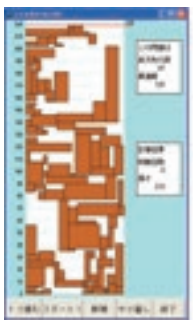
Exploring the complexity of discrete mathematics problems and developing algorithms

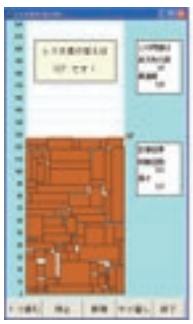
Topics in discrete mathematics, such as the graphs and networks used to represent systems, schedules to enhance the efficiency of production, and the logical analysis of large volumes of data, are closely related to applications of research results. We explore the complexity of the calculations used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

[Professor: NAGAMOCHI Hiroshi,
Assistant Professor: SHURBEVSKI Aleksandar]



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).

Outline

Applied Mathematical Systems

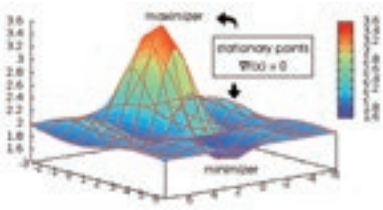
We carry out education and research regarding mathematical theories that are used in the analysis, planning, management and evaluation of a wide range of complex systems that occur in a computer-networked society and in modern production systems. Examples of these theories include mathematical programming, 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.

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.

[Professor: YAMASHITA Nobuo,
Assistant Professor: FUKUDA Ellen Hidemi]



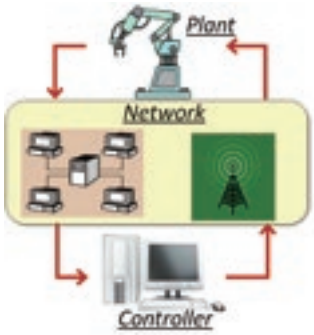
Optimal solutions of an unconstrained problem

Control Systems Theory

Mathematical approaches to modeling and control

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

[Professor; OHTA Yoshito, Associate Professor; KASHIMA Kenji,
Assistant Professor; OHKI Kentaro]



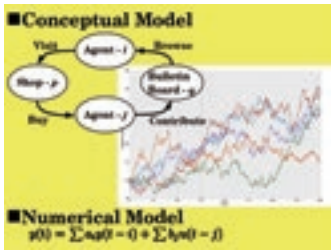
A sketch of networked control systems

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

Infusing information systems with intelligence

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

[Professor: YAMAMOTO Akira, Associate Professor: SATO Tatsuhiro]

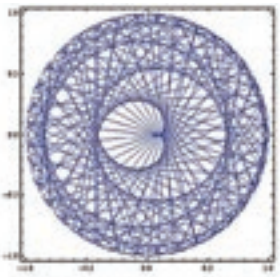


A conceptual and its numerical model

Mathematical Physics

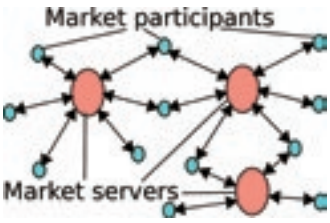
We look into mathematical models in physics, chemistry and biology that form the foundations of engineering and investigate those models from a dynamic system perspective by applying methods developed in statistical physics, dynamical systems theory, differential equations, probability theory, stochastic 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.

Various coupled multi-element systems



Chaos code for signal analysis and multiuser communications system

A conceptual diagram of a complex network



A model of the financial market and the market participants

Physical Statistics

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

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

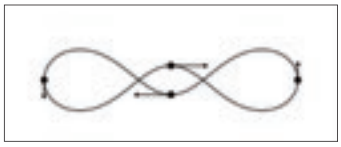
[Professor: UMENO Ken, Associate Professor: IGARASHI Akito, Assistant Professor: SATO Akihiro]

Dynamical Systems

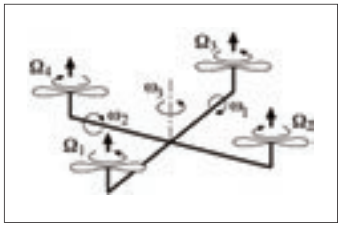
Looking into the world through dynamical systems theory

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

[Professor: YAGASAKI Kazuyuki, Associate Professor: SHIBAYAMA Mitsuru, Assistant Professor: YAMAGUCHI Yoshiyuki]



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

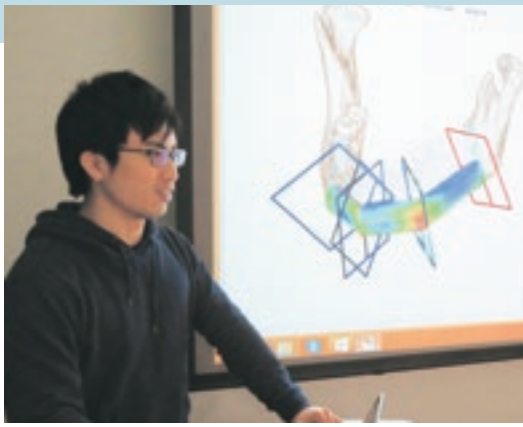


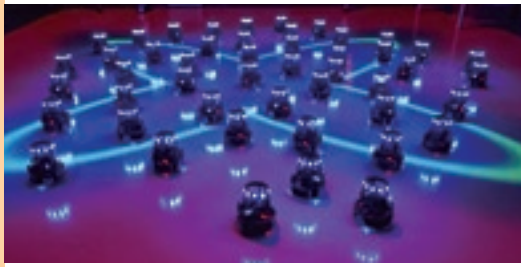
Mathematical model of quadrocopters

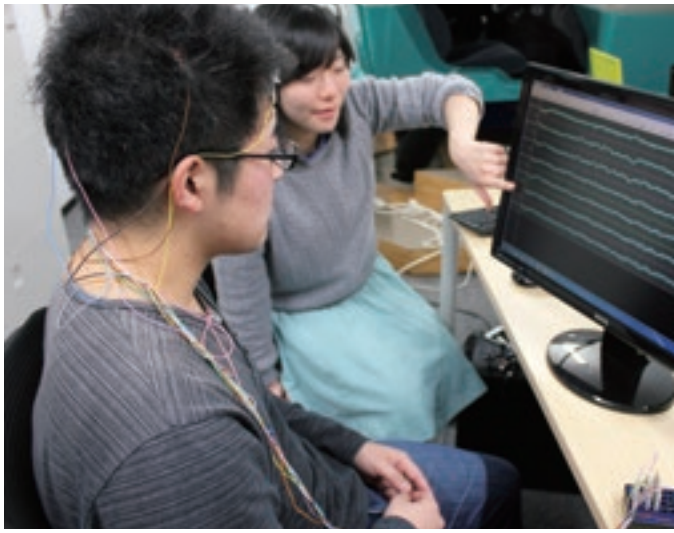
Department of Systems Science

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 understanding of complicated mutual interactions among human-beings, systems and environments.





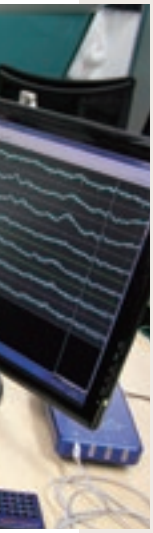


Information System Used in Medical Science and Treatment

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 information systems that contribute to the fields of medicine, medical treatment and biology.

MATSUDA Tetsuya
Department of Systems Science

1981 Faculty of Medicine, Kyoto University, M.D. 1988 Graduate School of Medicine, Kyoto University, Ph.D. After working at Third Division, Department of Internal Medicine, Kyoto University Hospital, Division of Cardiovascular Disease, University of Alabama at Birmingham, and Department of Medical Informatics, Kyoto University Hospital, he serves as Professor, Department of Systems Sciences, Graduate School of Informatics, Kyoto University from 2000. Research field covers magnetic resonance imaging physics, medical image processing, and cardiac simulation. He is a Committee member of JSMRM and JSMBE, board certified member of The Japanese Circulation Society, member of IEICE, ISMRM, SCMR and IEEE.



Systems Science is Interesting!

"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 things 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, 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.

TANAKA Toshiyuki
Department of Systems Science

Toshiyuki Tanaka received the B. Eng., M. Eng., and Dr. Eng. degrees in Electronics Engineering from the University of Tokyo, Tokyo, Japan, in 1988, 1990, and 1993, respectively. From 1993 until 2005, he was with the Department of Electronics and Information Engineering at Tokyo Metropolitan University, Tokyo, Japan. In 2005, he moved to the Department of Systems Science, Graduate School of Informatics, Kyoto University, Kyoto, Japan, where he is currently a professor. He received DoCoMo Mobile Science Prize in 2003, and Young Scientist Award from the Ministry of Education, Culture, Sports, Science and Technology, Japan, in 2005.

Outline

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
	Integrated Dynamical Systems	Nonlinear Systems Theory, Optimal Control, Real-Time Optimization, Human-Machine Systems	OHTSUKA Toshiyuki
Systems Synthesis	Adaptive Systems Theory	Adaptive, Learning, and Inference Theories and Their Application	TANAKA Toshiyuki
	Mathematical System Theory	Statistics, Machine Learning	SHIMODAIRA Hidetoshi
	Computational Intelligence Systems (Adjunct Unit)	Data Mining and Pattern Recognition Based on Statistical Machine Learning	UEDA Naonori
Systems Informatics	Information Systems	Stochastic modeling and performance analysis of information and service systems	
	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
Theory of Human-Machine Systems
Modeling and Problem-Solving of Complex Systems
Theory of Integrated Dynamical Systems
Adaptive Systems Theory
Statistical Systems Theory
Theory of Information Systems
Theoretical Life-Science
Medical Information Systems
Supercomputing (Advanced)
Advanced Study in Systems Science 1
Industrial Mathematics and Design
Advanced Study in Systems Science 2
Systems Sciences 1 (Advanced)
Systems Sciences 2 (Advanced)

Courses for the Doctoral Program

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

Teaching Staff

(M) : Academic Center for Computing and Media Studies

Professors

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

Associate Professors

NISHIHARA Osamu; MASUYAMA Hiroyuki; NAKAO Megumi; FUKAZAWA Keiichiro (M)

Senior Lecturers

OBA Shigeyuki

Assistant Professors

MARUTA Ichiro; FUJIWARA Koichi; HIRAOKA Toshihiro; IMAI Hirohiko; HIRAISHI Tasuku (M)

Human Machine Symbiosis

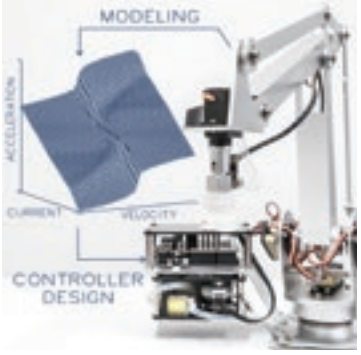
As computer networks spread and information systems become more sophisticated, the interrelationship between manmade systems (typified by machines) and humankind and the environment (including the natural environment and our social environment) is becoming ever more complicated and diverse. So we aim 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

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, Assistant Professor: MARUTA Ichiro]



A robot arm with 7 degrees of freedom

Human Systems

Aiming to Develop Human-Centered System Design Methodology

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

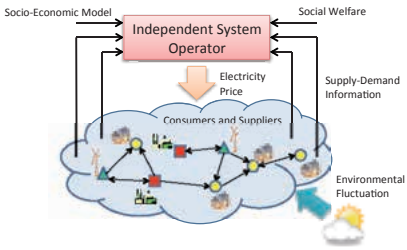
[Professor: KANO Manabu, Associate Professor: NISHIHARA Osamu, Assistant Professor: FUJIWARA Koichi]


Driver's EEG and ECG analysis

Integrated Dynamical Systems

Toward harmonious coexistence of a diversity of systems

For analysis and design of novel systems to realize symbiosis and synergy of various objects including humans, machines, societies, and environments, it is essential to find out universal principles in modeling, analysis, design, and control of dynamical systems. To this end, we conduct researches on novel methodologies to deal with nonlinearities 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]



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

Outline

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.

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]

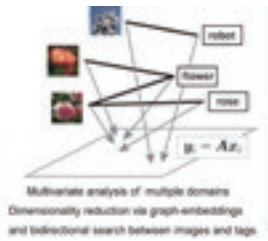
Digital communications as data mining: How one extracts the desired information from many intermixed signals is the key to high-performance digital communications.

Mathematical System Theory

Statistics and machine learning: Theory and applications

Statistics is playing important roles as a theoretical framework for fast-moving fields such as big data, data mining, and artificial intelligence. Statistics provides methodologies for inductive inference from data with consideration of randomness. Large amounts of data can now be easily obtained via high-throughput systems, and the field of machine learning, in particular, is growing rapidly. Through addressing real-world data, we are developing new statistical methods with emphasis on mathematics and programming skills.

[Professor: SHIMODAIRA Hidetoshi]



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

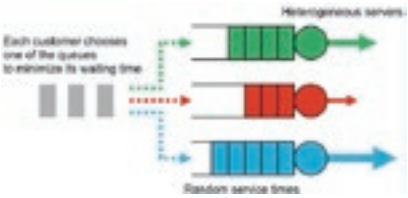
The division performs the education and research from the standpoints of systems science and information science for solving a variety of problems in various kinds of practical systems. Current education and research program is concerned with communication systems, brain and neural systems, and systems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

Information Systems

For optimal decision-making in information and service systems

There are various information and service systems in which an unspecified number of users compete against each other. In respect of these systems, users and service providers are frequently forced to make decisions based on unverified information. For optimal decision-making under such uncertain circumstances, we develop methods of system modeling and simulation using stochastic processes, and we also study analysis and performance evaluation of mathematical models through applied probability, queueing, statistics, optimization, game theory, etc.

[Associate Professor: MASUYAMA Hiroyuki]



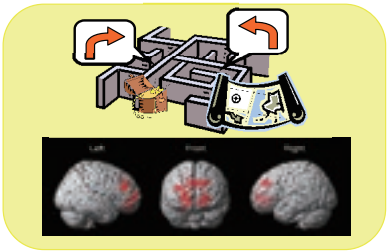
Strategic multiple queueing model

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]



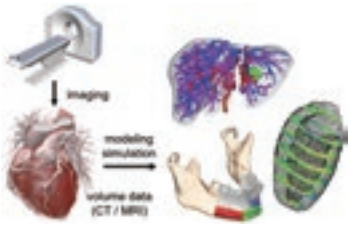
A model of the decision-making process in an uncertain environment, and images of information processing within the brain

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, Assistant Professor: IMAI Hirohiko]



Medical image processing and modeling for diagnosis and treatment

Outline

Computational Neuroscience Adjunct Unit

Create a brain in order to understand the brain

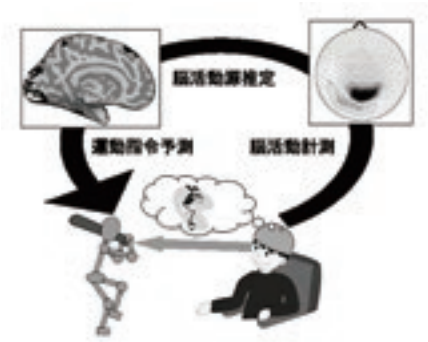
(a) Humanoid Robot

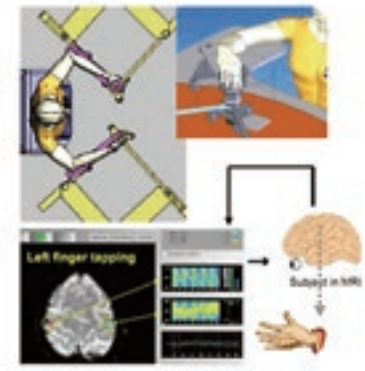
The goal of our study is to control robots by thoughts in the brain. This study is expected to contribute to the connection of humans and robots as a future telecommunication device and to the development of an assistive device for the recovery of motor functions in humans. We aim to understand brain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

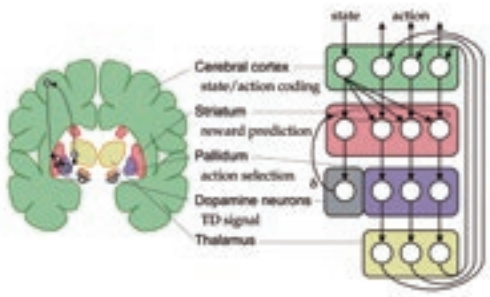
[Professors: FUKAI Tomoki and ISHII Shin]

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)

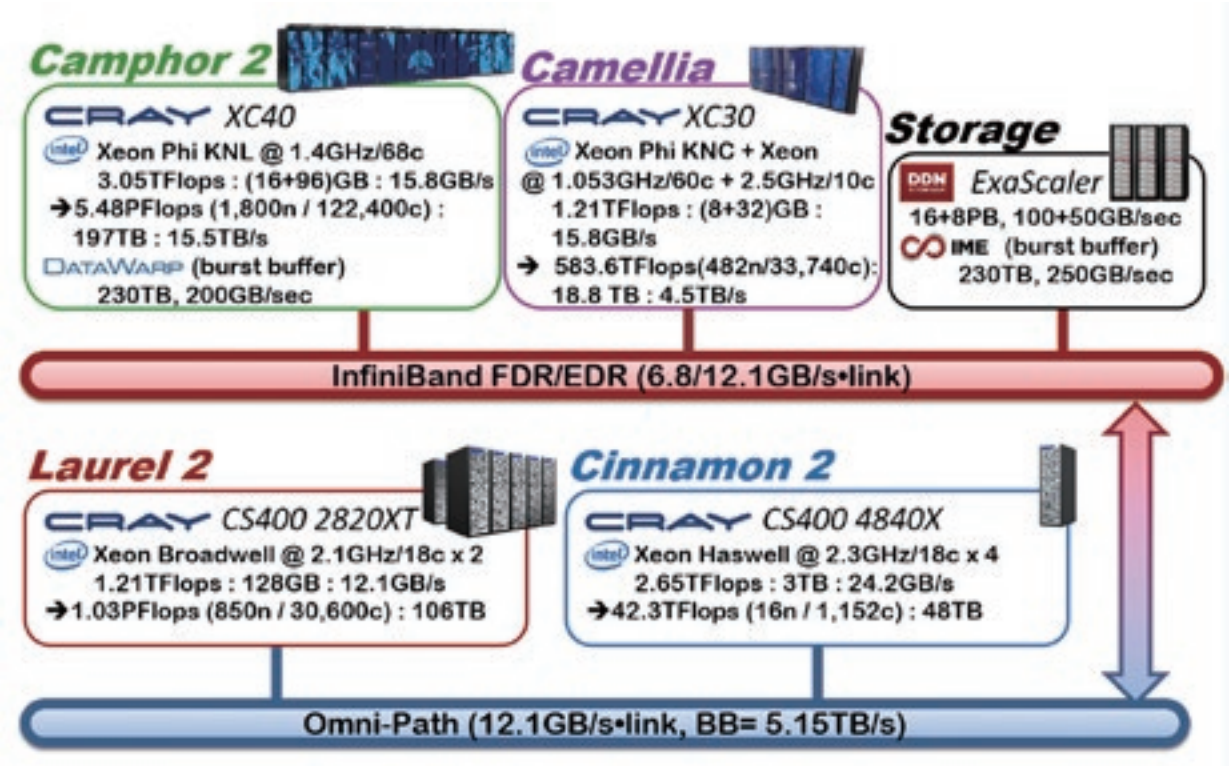
(Academic Center for Computing and Media Studies)

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, Associate Professor: FUKAZAWA Keiichiro
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.

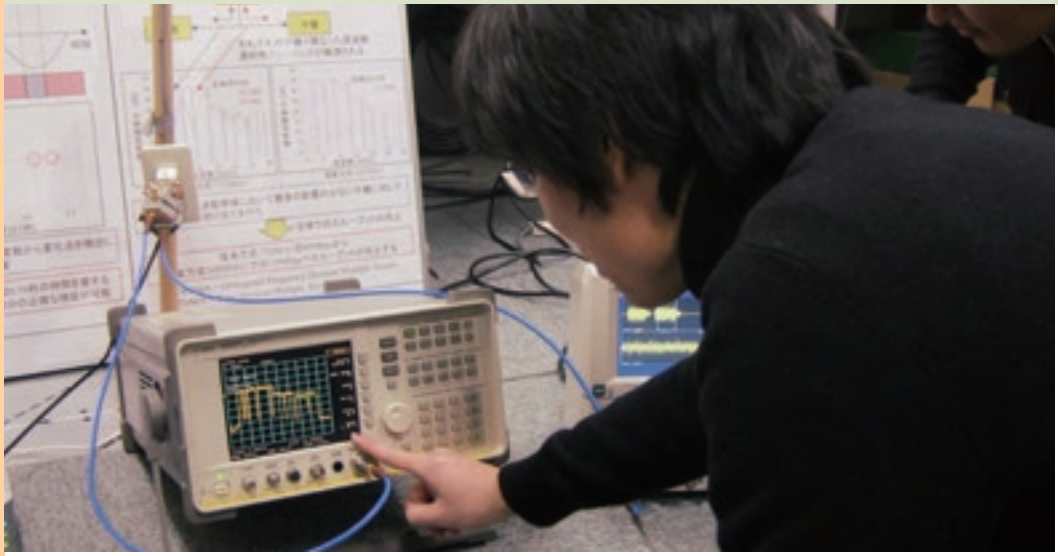


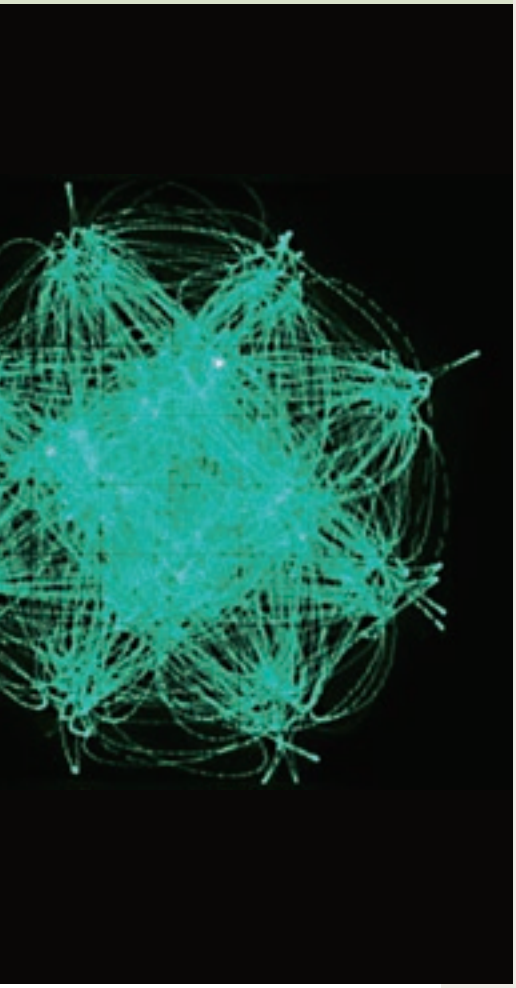
Supercomputer System in ACCMS

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.





"Invisiblizing" software

Some people say "Software weighs nothing." What do you think? Here is an anecdote from 1960s, at the dawn of the computer age: "How much does the software on this airplane weigh?" "Nothing." "That's ridiculous. It costs a million dollars and doesn't weigh anything? What about that deck of punched cards? It does weigh something." "See those holes on the cards? Those holes are the only part of the software that actually goes into the plane."

Some people say "Software is invisible." What do you think? Well, even if it is holes, it's very questionable that software is really invisible. Indeed, software bugs frequently annoy us, making software "visible". Software---especially one that works as part of social infrastructure---should be so invisible that we don't even notice its existence.

Our research group conducts a wide range of research to contribute to improving safety and dependability of software, thereby "invisiblizing" software. We develop new programming languages and automated program verification techniques based on theory of computer programs, which we also study.

The Department of Communications and Computer Engineering focuses on education and research in areas such as future computer systems, communications, and integrated systems, which are also "invisible" infrastructure technology. Broad topics ranging from academic research to cutting-edge industrial problems are waiting to challenge you. Why don't you aim for being a "world-visible" researcher at our Department?

IGARASHI Atsushi
Department of Communications and Computer Engineering

He received his B.S., M.S., and Ph.D degrees from Department of Information Science, University of Tokyo in 1995, 1997, and 2000, respectively. He joined the faculty of Graduate School of Informatics, Kyoto University in 2002 as a Lecturer after two years as a Research Associate at Graduate School of Arts and Sciences, University of Tokyo. He became an Associate Professor in 2006 and a Professor in 2012. His main research interest is in principles of programming languages. He received the 20th Japan IBM Science Prize in Computer Science in 2006, the Young Scientists' Prize, the Commendation for Science and Technology by the Japan Minister of Education, Culture, Sports, Science and Technology in 2009, the 1st Microsoft Research Japan New Faculty Award in 2009, and the Dahl-Nygaard Junior Prize in 2011.

Outline

Divisions and Groups

Division	Group	Research and Education Topics	Professor
Computer Engineering	Logic Circuits, Algorithms and Complexity Theory	Logic Circuits, Algorithms and Complexity Theory	
	Computer Architecture	Arithmetic Circuits, Embedded System Design, and Superconducting Processors	TAKAGI Naofumi
	Computer Software	Programming Language Systems and Parallel Processing	IGARASHI Atsushi
Communications Systems Engineering	Digital Communications	Highly Reliable and Secure Broadband Digital Communication 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	OKI Eiji
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)	Remote Sensing Engineering	Atmospheric Measurement and Geophysical Environmental Information by Radio Waves, Light, and Acoustic Waves Using Electronic Engineering	YAMAMOTO Mamoru
	Atmospheric Observations		

Graduate Curriculum

Courses for the Master's Program

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

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

(S): Research Institute for Sustainable Humanosphere

Professors

TAKAGI Naofumi; IGARASHI Atsushi; HARADA Hiroshi; MORIKURA Masahiro; OKI Eiji; SATO Takashi; ONODERA Hidetoshi; SATO Toru; YAMAMOTO Mamoru (S)

Associate Professors

LE GALL François; TAKAGI Kazuyoshi; SUENAGA Kohei; MURATA Hidekazu; MATSUMURA Takeshi; YAMAMOTO Koji; SHINKUMA Ryoichi; ISHIHARA Toru; HASHIGUCHI Hiroyuki (S)

Assistant Professors

TAMAKI Suguru; TAKASE Hideki; UMATANI Seiji; MIZUTANI Keiichi; NISHIO Takayuki; HIROMOTO Masahuki; SHINTANI Michihiro; HASHIMOTO Taishi; FURUMOTO Jun-ichi (S); YABUKI Masanori (S)

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

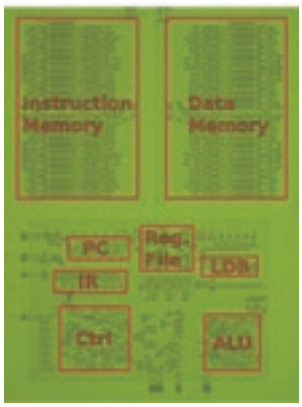
The challenge of difficult computational problems

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 (π) 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.

[Associate Professor: LE GALL François, Assistant Professor: TAMAKI Suguru]

Computer Architecture

Advanced computing mechanisms and design technologies



CORE e4: the world's first superconducting RSFQ stored-program microprocessor

We conduct education and research on high-speed and low-power computing mechanisms of the next generation and design technologies for them. Our research topics include arithmetic algorithms suitable for FPGA (reconfigurable hardware device) implementation, software-oriented design environment for embedded systems based on programmable SoCs, system software technologies for low-power embedded real-time systems, and, logical design and design methodologies of superconducting microprocessors/accelerators.

[Professor: TAKAGI Naofumi, Associate Professor: TAKAGI Kazuyoshi, Assistant Professor: TAKASE Hideki]

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]

Outline

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

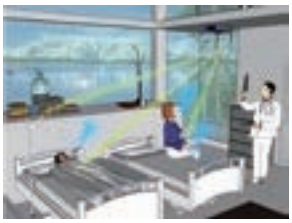
Wireless communication networks, accelerated by cellular radio together with short-range wireless communications and RFID tag technologies, for instance, have been advancing significantly towards the goal of so-called ubiquitous networks. That is, we are on the verge of an era when people can enjoy various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

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

Toward ultimate form of information and commucation networks as social infrastructure

In the era of Internet of Things (IoT), big data, and artificial intelligent, evolution of information and communication networking technologies are required.
Information and communication networks connect people and things, including smart phones that collect various data, IoT devices, data centers, clouds bringing values to people, and applications. They are expected to maximize the benefits to people. This laboratory is working on the research and development of high-speed, reliable, and flexible networking technologies, with both theoretical and practical approaches, considering various aspects of social, information, devices, and energy.

[Professor: OKI Eiji, 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, Associate Professor: HIROMOTO Masayuki, Associate Professor: SHINTANI Michihiro]

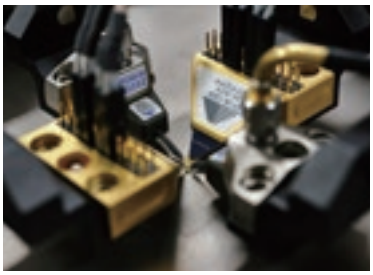
A reconfigurable LSI fabricated using 65nm process technology and its evaluation board

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 energyefficient embedded systems.

[Professor: ONODERA Hidetoshi, Associate Professor: ISHIHARA Tohru]



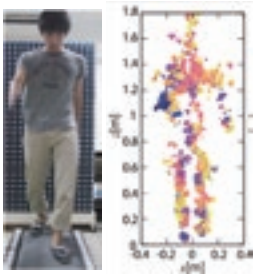
A test chip originally designed and its probing test

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 atmospheric radars.

[Professor: SATO Toru, Assistant Professor: HASHIMOTO Taishi]



Outline

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.

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]

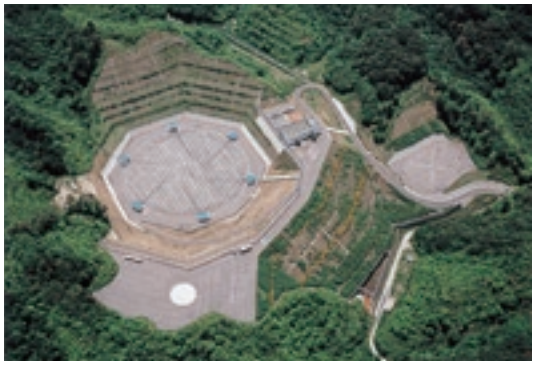
Equatorial Atmosphere Radar in West Sumatra, Indonesia. Its size is about the same as that of an MU radar.

Atmospheric Observations

Towards developing new observation techniques to obtain atmospheric environmental information

We are developing new techniques to observe the atmosphere using radio waves, light, and acoustic waves, and conduct research and education to collect, process, and disseminate global observational atmospheric data. More specifically, our research topics include 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.

[Assistant Professor: FURUMOTO Jun-ichi,
Assistant Professor: YABUKI Masanori]

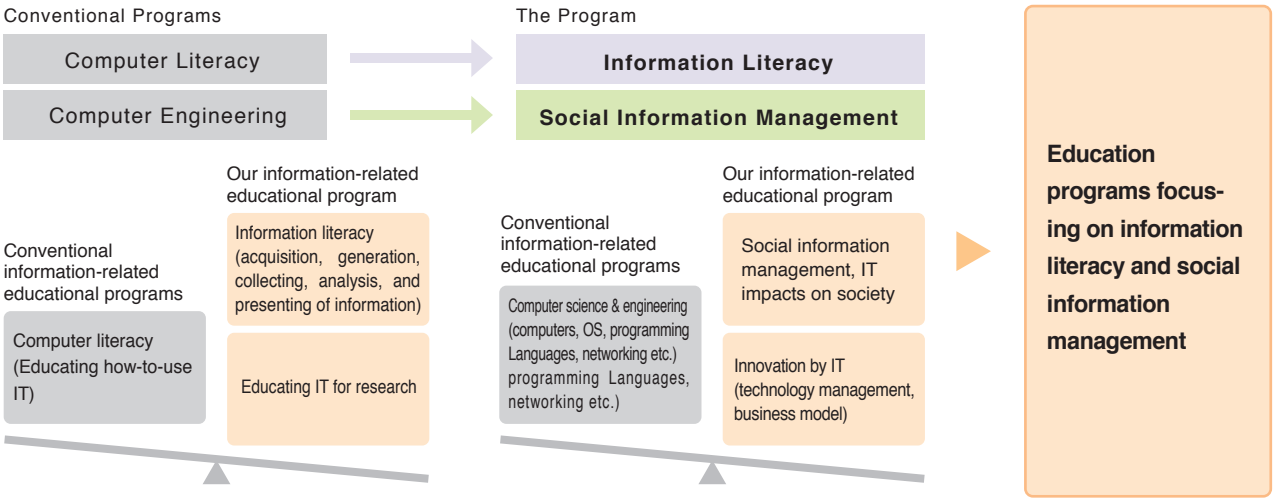


MU radar in Shigaraki, Koka City, Shiga Prefecture.
The diameter of the antenna is 103 m.

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

The Advanced Information-Related Education & Digital Education Infrastructure Unit was established in Kyoto University C-PiER to implement the budget request project: Fostering Global Human Resources by Innovating Undergraduate/Graduate-level Information-related Education & Digitized Education of the graduate school of informatics, Kyoto University. The unit develops and provides an innovative information-related educational program and digitized education environment such as active-learning classrooms and online lectures.

Innovative Educational Programs



Digitized Education Environment

BYOD Classroom Learning

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

Conventional classroom learning

Learning using tablets
Active learning

Online Lectures and Digital Textbooks

- Digital Textbooks (Japanese and English)
- Online Lectures (MOOC)

Digital textbooks under development

Online Lectures

Faculties

YAMAMOTO Akihiro
Unit Leader
Professor Graduate School of Informatics

MAEGAWA Yoshikazu
Assoc. Professor
Graduate School of Management

TAJIMA Keishi
Professor Graduate School of Informatics

EBARA Yasuo
Assoc. Professor
Academic Center for Computing and Media Studies

ASANO Yasuhito
Assoc. Professor
Graduate School of Informatics

KATO Makoto
Assist. Professor
Graduate School of Informatics

KIMURA Kinji
Assoc. Professor
Graduate School of Informatics

SEKIDO Hiroto
Assist. Professor
Graduate School of Informatics

Courses

[Liberal Arts Courses]

- Fundamentals of Informatics
- Fundamentals of Information Media
- Introduction to Data Analysis
- Fundamentals & Practice of Informatics
- Practice of Data Analysis
- Introduction to Information & Intellectual Property
- Innovation and Information
- Information and Enterprises

[Graduate Courses]

- Information Analysis and Management
- Practice of Information Analysis & Management
- Media Information Processing
- Service Modeling
- Computation Science for Big Data
- Introduction to Computational Science
- Information and Intellectual Property
- Practice of Computational Science A
- Practice of Computational Science B

Contact

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

Kyoto University Collaborative Graduate Program in Design

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

Students enrolled in this program conduct their studies around the six core disciplines of informatics,mechanical engineering, architecture, management, 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 either a Doctorate degree (Ph.D.) or a Doctoral Degree in informatics. As for the latter degree,certificate of the completion of the Program for Leading Graduate Schools 'Collaborative Graduate Program in Design' is specified in the diploma.

Participant Organizations

Graduate School of Education (Division of Educational Studies), Graduate School of Engineering (Department of Architecture and Architectural Engineering, Department of Mechanical Engineering and Science, Department of Micro Engineering, and Department of Aeronautics and Astronautics), Graduate School of Informatics (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 Graduate School of Management (Department of Business Administration, Department of Management Science)

Partner Organizations

Kyoto City University of Arts, NEC Corporation, Nippon Telegraph and Telephone Corporation (NTT), Ernst & Young Institute Co.,Ltd., Panasonic Corporation, Mitsubishi Electric Corporation, and about 60 members in Design Innovation Consortium (Osaka Gas Co., Ltd., OMRON Corporation, Kawasaki Heavy Industries Ltd., Sony Corporation, Toshiba Corporation, Daikin Industries Ltd., Takenaka Corporation, Toray Industries Inc., Nippon Telegraph and Telephone West Corporation (NTT WEST), Nomura Research Institute, HAKUHODO Inc., Yokogawa Electric Corporation , 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.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 earn at least 30 credits from the courses specified by the departments; to receive the appropriate instructions through the classes; and to pass the course examinations and the assessment of Master's 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 earn at least 6 credits from the courses specified by the departments; to receive the appropriate instructions through the classes; and to pass the course examinations and the assessment of Doctoral thesis.

Entrance Examination

The academic year begins in April. In general, a Master's degree requires two academic years of study, and a Doctoral degree three years. Admission to graduate programs 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 in July and August. Supplementary examinations may be held in December and February.

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.

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 Advanced Mathematical Sciences	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. Students may enroll in this graduate school concurrently with their professional responsibilities.

For further information, please contact:

Graduate School of Informatics
Kyoto University
Yoshida-Honmachi, Sakyo-ku,
Kyoto 606-8501 JAPAN
Tel. +81 75-753-4894,5500
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.

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