A large, white wireframe head in profile, facing right, is the central focus. The background is a dark blue field with a network of glowing blue lines and nodes. In the bottom right corner, there is a collage of images: a bamboo forest, a stone path, and a green lawn with stepping stones, all partially obscured by a geometric shape composed of several triangles in shades of blue, purple, and magenta.

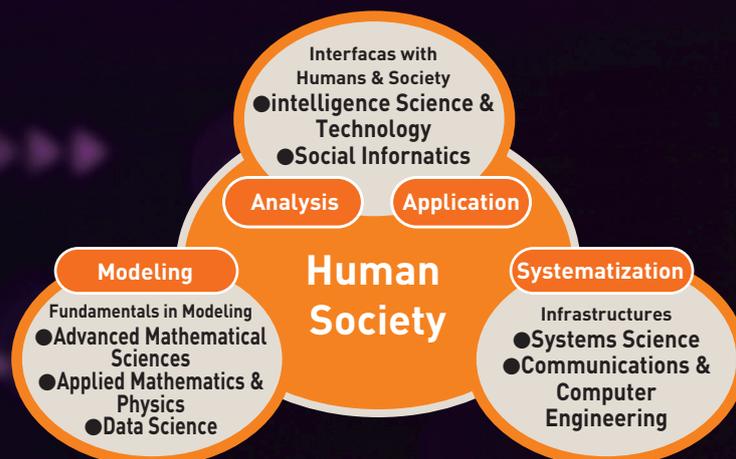
**2025**

**Kyoto University  
Graduate School  
of Informatics**

# From Kyoto to the world.



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



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List of Departments, Divisions and Groups  
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## Definition of Informatics

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

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

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

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

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

# Welcome to Graduate School of Informatics

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

*Dean, Graduate School of Informatics*

*Atsushi Igarashi*



## *What is Informatics?*

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

As mentioned, our graduate school was the first in Japan to define itself using the term “informatics.” Up to that time, most schools and departments in Japan in this general field used names containing “computer science/engineering” or “information science,” but between the late 1990s and early 2000s, Kyoto University and some other leading universities, including Hokkaido University, Tohoku University, The University of Tokyo, Tokyo Institute of Technology, Nagoya University, Osaka University, and Kyushu University established graduate

schools in information-related science, typically with names like “Graduate School of Information Science/Engineering” or “Graduate School of Information Science.” Only Kyoto University adopted the broader term “informatics.” In fact, two years before Graduate School of Informatics was established, the “School of Informatics and Mathematical Science” was created in the Faculty of Engineering through a merger of the School of Information Science and the School of Applied Mathematics and Physics. The use of “informatics” was very unusual at the time. These name choices were motivated by the desire of the people involved in setting up this graduate school to establish a broader discipline of “informatics” to transcend the limits of the conventional disciplines of “information science/engineering” or “information science.”

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

## *Education and Research in Graduate School of Informatics*

Graduate School of Informatics is one of the largest graduate schools at Kyoto University, with a current intake (per academic year) of 240 students for the Master's program and 65 students for the Doctoral program. The graduate school consists of seven "courses" of study under the "major" of informatics.

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

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

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

students naturally cultivate a deeper knowledge of their field of specialization through the research guidance of their academic advisors, but they also acquire a comprehensive academic vision through seminar subjects in each course.

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

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

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

### *Our Reorganization*

In April 2023, on the 25th anniversary of its establishment, Kyoto University Graduate School of Informatics was reorganized. The six existing departments (Intelligence Science and Technology, Social Informatics, Advanced Mathematical Sciences, Applied Mathematics and Physics, Systems Science, and Communications and Computer Engineering) were merged into a single Department of Informatics. The educational programs of the previous six departments were transformed into “courses” and a new “Data Science Course” was added (making a total of seven courses). At the same time, the total student intake was increased. Admissions capacity was increased from 189 to 240 students per academic year for the master’s program, and in April 2025 it was increased from 60 to 65 students per academic year for the doctoral program.

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

### *Concluding Remarks*

This brief overview of Graduate School of Informatics is focused on educational programs. Of course, a wide variety of research in informatics is also conducted within the school. The

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

### *Atsushi Igarashi*

*Dean, Graduate School of Informatics*

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

# Courses in Graduate School of Informatics



Applied Mathematics and  
Physics Course

- Applied Mathematical Analysis
- Discrete Mathematics
- System Optimization
- Control Systems Theory
- Physical Statistics
- Dynamical Systems
- Applied Mathematical Modeling  
(Adjunct Unit)

Communications and Computer Engineering Course

- Computer Algorithms
- Computer Architecture
- Computer Software
- Digital Communications
- Integrated-Media Communications
- Intelligent Communication Networks
- Processing Architecture and Systems
- Low-power Integrated Circuit Design
- Integrated Computing Systems
- Remote Sensing Engineering
- Atmospheric Observations
- Supercomputing
- Multimedia and Secure Networking

Systems Science Course

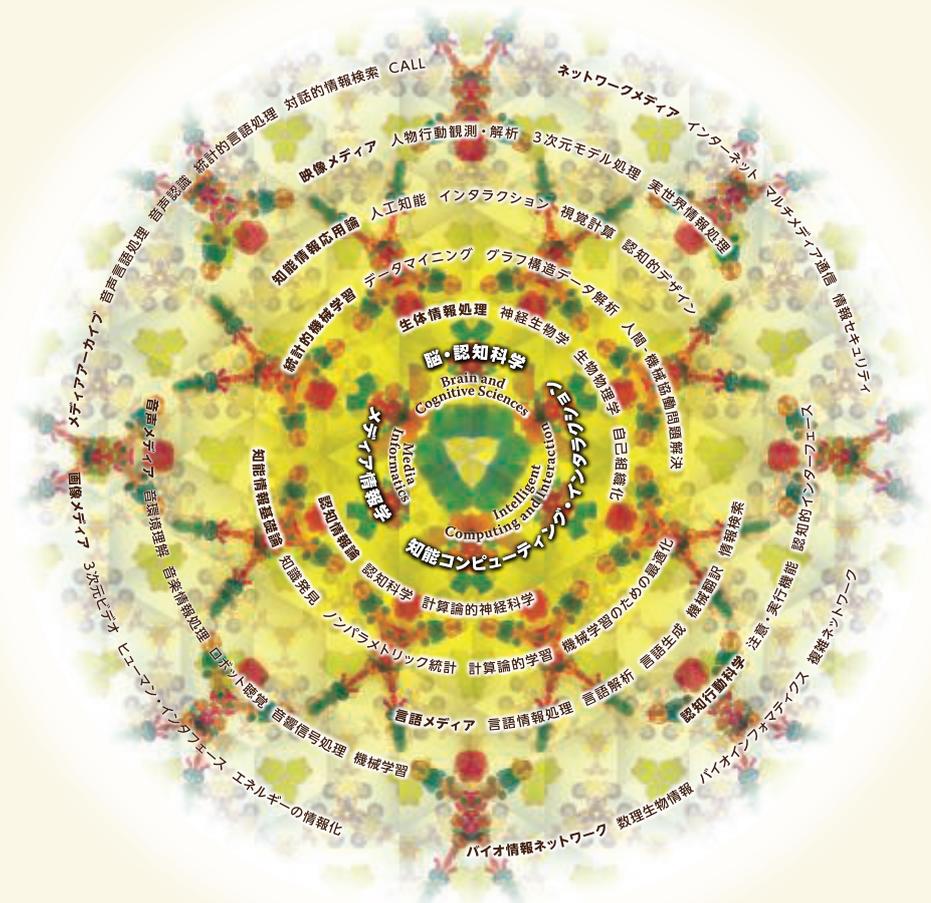
- Mechanical Systems Control
- Human Systems
- Integrated Dynamical Systems
- Mathematical Information Systems
- Statistical Intelligence
- Learning Machines
- Integrated Systems Biology
- Biocybernetics
- Computational Neuroscience  
(Adjunct Unit)

Data Science Course

- Statistical Mathematics
- Statistical Inference
- Information-Theoretic Learning
- Signal and Information Processing
- Applied Machine Learning
- Medical and Healthcare Data Science
- Computational Intelligence Systems  
(Adjunct Unit)

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

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



## Welcome to Intelligence Science and Technology Course

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

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

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

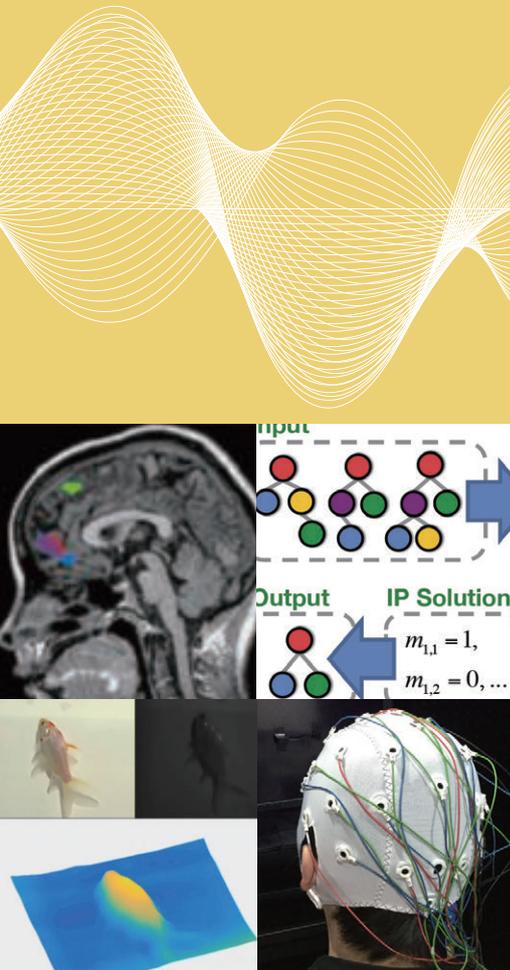


### *Tadahiro Taniguchi*

*Professor, Intelligence Science and Technology Course*

Received a Ph.D. in Engineering from the Graduate School of Engineering, Kyoto University in 2006.

After serving as Professor at the College of Information Science and Engineering, Ritsumeikan University, and as Visiting General Chief Scientist at Panasonic Holdings Corporation, he assumed his current position in 2024.



**Outline**

**Group and Teaching Staff**

Group	Teaching Staff
<b>Neuroinformatics</b>	Yukiyasu Kamitani/Professor Yukiori Goto/Associate Professor Hiroshi Hosokawa/Senior Lecturer Yoshihiro Nagano/Assistant Professor Shingo Maegawa/Assistant Professor
<b>Psychoinformatics</b>	Takatsune Kumada/Professor Ryoichi Nakashima/Associate Professor
<b>Cognitive Informatics</b>	Shin'ya Nishida/Professor Kiyofumi Miyoshi/Assistant Professor
<b>Computational Cognitive Neuroscience (Adjunct Unit)</b>	Hiroyuki Nakahara/Adjunct Professor Wataru Sato/Adjunct Professor(RIKEN)
<b>Computational Intelligence</b>	Akihiro Yamamoto/Professor Nozomi Akashi/Assistant Professor
<b>Collective Intelligence</b>	Hisashi Kashima/Professor Koh Takeuchi/Senior Lecturer Kyohei Atarashi/Assistant Professor
<b>Symbol Emergence Systems</b>	Tadahiro Taniguchi/Professor Masatoshi Nagano/Assistant Professor
<b>Language Media Processing</b>	Sadao Kurohashi/Program-Specific Professor Yugo Murawaki/Associate Professor Chenhui Chu/Program-Specific Associate Professor Fei Cheng/Program-Specific Senior Lecturer Huang Yin Jou /Program-Specific Assistant Professor
<b>Speech and Audio Processing</b>	Tatsuya Kawahara/Professor Keisuke Imoto/Associate Professor Koji Inoue/Assistant Professor Keiko Ochi/Program-Specific Assistant Professor
<b>Computer Vision</b>	Ko Nishino/Professor Ken Sakurada/Associate Professor Ryo Kawahara/Associate Professor
<b>Human Sensing</b>	Yuichi Nakamura/Professor Kazuaki Kondo /Associate Professor Kei Shimonishi/Assistant Professor
<b>Text Media</b>	Shinsuke Mori/Professor Hirotaka Kameko/Assistant Professor
<b>Biological Information Networks</b>	Tatsuya Akutsu/Professor Takeyuki Tamura/Associate Professor Motomu Matsui/Assistant Professor

**Curriculum of Intelligence Science and Technology Course**

Doctoral Program (Informatics)							
3 <sup>rd</sup>	Doctoral Thesis						
2 <sup>nd</sup>	<b>Subjects provided by the Course (total 6 credits including 4 credits from seminars)</b> Seminar on Intelligence Science and Technology, Adv. E (Mandatory, 2 credits) Seminar on Brain and Cognitive Sciences, Adv. A, B, E, Seminar on Cognitive System, Adv. A, B, E, Seminar on Intelligence Media, Adv. A, B, E, Seminar on Application of Multimedia, A, B Adv. E, Seminar on Bio-system Informatics, A, B Adv. E (2 credits each)						
1 <sup>st</sup>							
Research Guidance							
Master's Program (Informatics)							
Master's Thesis							
2 <sup>nd</sup>	<b>Subjects provided by the Course (optional 6 credits or more)</b>						
1 <sup>st</sup>							
<table border="1"> <tr> <td> <b>Advanced Subjects</b>                      Seminar on Cognitive Science, Computational Cognitive Neuroscience, Pattern Recognition Adv. E, Speech Processing Adv. E, Language Information Processing Adv., Computer Vision E, Visual Interface, Bioinformatics Adv. (2 credits each)                 </td> <td> <b>Seminars (4 credits, Mandatory)</b>                      Seminar on Intelligence Science and Technology II E                      Seminar on Intelligence Science and Technology IV E (Assigned to M2, 2 credits each)                      Seminar on Intelligence Science and Technology I, E,                      Seminar on Intelligence Science and Technology III E (Assigned to M1, 2 credits each)                 </td> </tr> <tr> <td> <b>Basic Subjects</b>                      Introduction to Cognitive Science, Introduction to Information Science, Introduction to Bioinformatics (2 credits each)                 </td> <td> <b>Recommended Subjects Provided by Other Courses</b>                      Computational learning theory                      Statistical learning theory                 </td> </tr> <tr> <td colspan="2"> <b>General subjects provided by the School</b>                      Perspectives in Platform Studies (2 credits), Computational Science, Introduction (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credits), Information Analysis and Management, Exercise (1 credit), Social Contributions through Informatics E (1 credit) Internship in the Field of Informatics E (1 credit)                 </td> </tr> </table>		<b>Advanced Subjects</b> Seminar on Cognitive Science, Computational Cognitive Neuroscience, Pattern Recognition Adv. E, Speech Processing Adv. E, Language Information Processing Adv., Computer Vision E, Visual Interface, Bioinformatics Adv. (2 credits each)	<b>Seminars (4 credits, Mandatory)</b> Seminar on Intelligence Science and Technology II E Seminar on Intelligence Science and Technology IV E (Assigned to M2, 2 credits each) Seminar on Intelligence Science and Technology I, E, Seminar on Intelligence Science and Technology III E (Assigned to M1, 2 credits each)	<b>Basic Subjects</b> Introduction to Cognitive Science, Introduction to Information Science, Introduction to Bioinformatics (2 credits each)	<b>Recommended Subjects Provided by Other Courses</b> Computational learning theory Statistical learning theory	<b>General subjects provided by the School</b> Perspectives in Platform Studies (2 credits), Computational Science, Introduction (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credits), Information Analysis and Management, Exercise (1 credit), Social Contributions through Informatics E (1 credit) Internship in the Field of Informatics E (1 credit)	
<b>Advanced Subjects</b> Seminar on Cognitive Science, Computational Cognitive Neuroscience, Pattern Recognition Adv. E, Speech Processing Adv. E, Language Information Processing Adv., Computer Vision E, Visual Interface, Bioinformatics Adv. (2 credits each)	<b>Seminars (4 credits, Mandatory)</b> Seminar on Intelligence Science and Technology II E Seminar on Intelligence Science and Technology IV E (Assigned to M2, 2 credits each) Seminar on Intelligence Science and Technology I, E, Seminar on Intelligence Science and Technology III E (Assigned to M1, 2 credits each)						
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<table border="1"> <tr> <td> <b>Seminars and exercises for Master's thesis (Mandatory 8 credits)</b>                      Advanced Study in Intelligence Science and Technology 2E (Assigned to M2, 6 credits)                      Advanced Study in Intelligence Science and Technology 1 E (Assigned to M1, 2 credits)                 </td> <td>                     Specific subjects provided by the school                 </td> </tr> </table>		<b>Seminars and exercises for Master's thesis (Mandatory 8 credits)</b> Advanced Study in Intelligence Science and Technology 2E (Assigned to M2, 6 credits) Advanced Study in Intelligence Science and Technology 1 E (Assigned to M1, 2 credits)	Specific subjects provided by the school				
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<table border="1"> <tr> <td> <b>Interdisciplinary subjects of the Perspectives in Informatics (Mandatory 2 credits or more, up to 4 credits)</b>                      Perspectives in Informatics 1 Perspectives in Informatics 2                      Perspectives in Informatics 3E Perspectives in Informatics 4E                      Perspectives in Informatics 5E (2 credits each)                 </td> </tr> </table>		<b>Interdisciplinary subjects of the Perspectives in Informatics (Mandatory 2 credits or more, up to 4 credits)</b> Perspectives in Informatics 1 Perspectives in Informatics 2 Perspectives in Informatics 3E Perspectives in Informatics 4E Perspectives in Informatics 5E (2 credits each)					
<b>Interdisciplinary subjects of the Perspectives in Informatics (Mandatory 2 credits or more, up to 4 credits)</b> Perspectives in Informatics 1 Perspectives in Informatics 2 Perspectives in Informatics 3E Perspectives in Informatics 4E Perspectives in Informatics 5E (2 credits each)							
Prior to admission	<table border="1"> <tr> <td>Bioinformatics</td> <td>Psychology</td> <td>Computational Science</td> <td>Electrical and Electronic Engineering</td> <td>Required basic background of either subject on the left</td> </tr> </table>	Bioinformatics	Psychology	Computational Science	Electrical and Electronic Engineering	Required basic background of either subject on the left	
Bioinformatics	Psychology	Computational Science	Electrical and Electronic Engineering	Required basic background of either subject on the left			

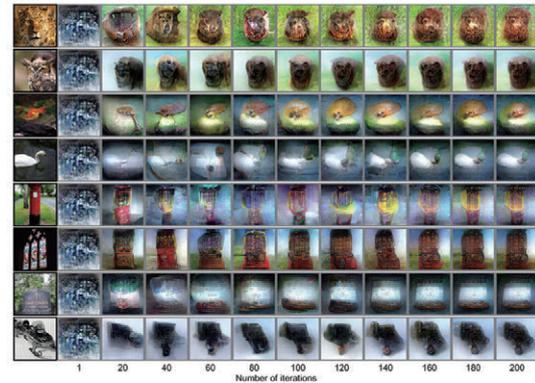
Note: Courses marked with the letter "E" will be provided in English.

## Brain and Cognitive Sciences

### *Decoding neural codes*

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

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



## 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.

[Takatsune Kumada , Ryoichi Nakashima]



An experiment examining eye and action coordination

**Outline**

**Cognitive Informatics**

*Understanding Human Sensory and Cognitive Information Processing*

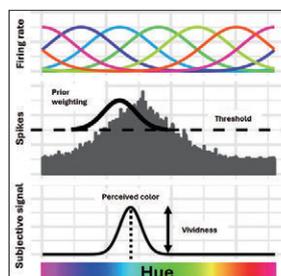
Our lab aims to understand the principles of human information processing related to sensation, perception, and metacognition and their underlying neural mechanisms by means such as psychophysics and computer simulations. By comparing human brains with

artificial intelligence systems, we attempt to reveal the characteristics of human information processing. We also work on developing information technology that leverages human characteristics.

[Shin'ya Nishida , Kiyofumi Miyoshi]



Material perception is one of our research topics.



Neural coding model for subjective color experience

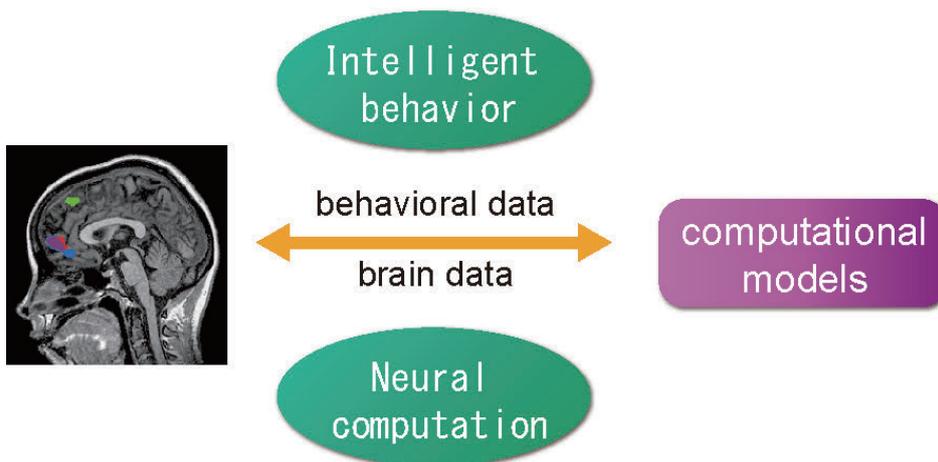
**Computational Cognitive Neuroscience (Adjunct Unit)**

*Neural information processing and computational models*

We aim to understand the computational principles that underlie the way neural systems realize adaptive behavior and complex minds: e.g., decision-making, reinforcement learning, motivation and emotion, and social behaviors. Our approaches are tightly linked to statistical and information science including machine learning and neural networks, as well as to questions in neuroscience and psychology. To address our questions, we build computational

and mathematical models, and develop data analysis methods for linking those behavioral functions and brain signals through computations. We use human fMRI to examine neural signals and computations, combined with those modeling and quantitative methods. We also seek to use our insights to be applied to constructing brain-based intelligence.

[RIKEN: Hiroyuki Nakahara , Wataru Sato]



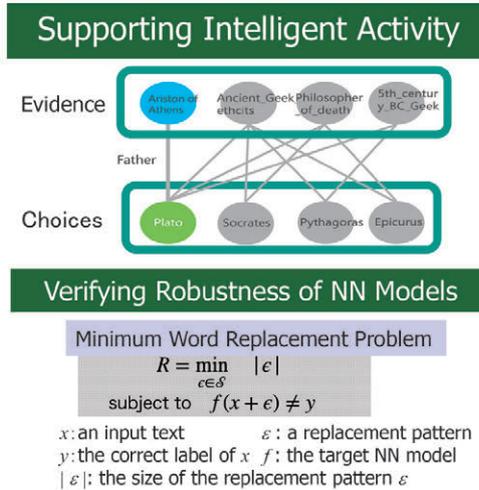
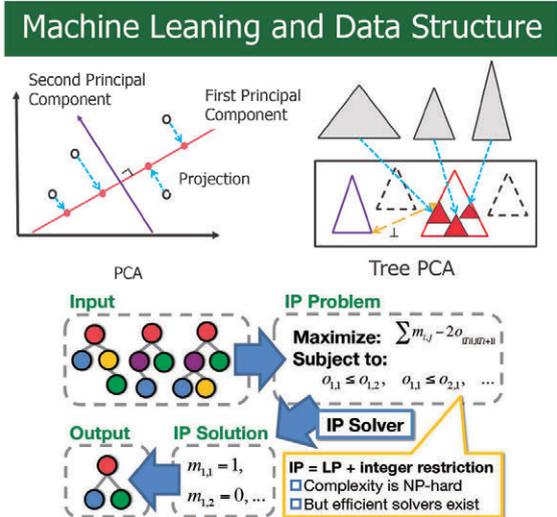
## Computational Intelligence

### Formulation of principles to support intelligent information processing

We will formalize the intelligent information processing seen in human activities and conduct studies on the basic principles that underlie these processes, as well as realization methods. Specifically, this will involve education and research relating to artificial intelligence information

processing such as inductive logic, knowledge discovery, hypothetical reasoning, and evolvable computers, using mathematical logic, inference procedures, machine learning theories and self-organization.

[Akihiro Yamamoto , Nozomi Akashi]



Intelligence Science and Technology Course

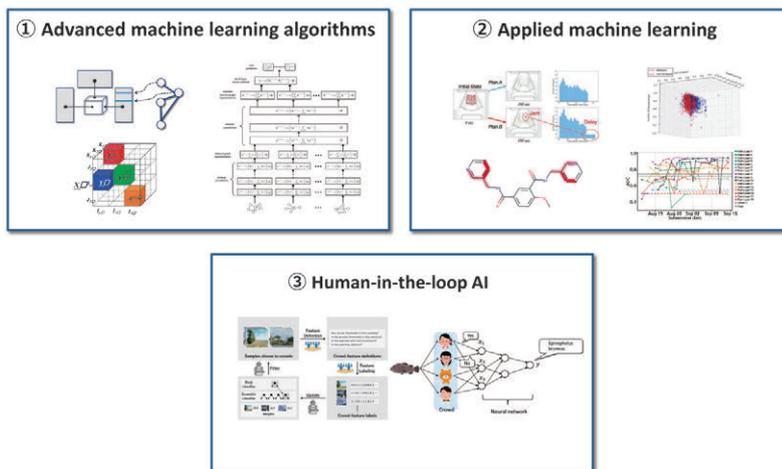
## Collective Intelligence

### Machine Learning That Matters

Our research focus is on the development of fundamental technologies for intelligent information technology, with a focus on machine learning, and their real-world applications. While pursuing R&D on new problems and methods of machine learning and

data analysis, we also tackle various challenges in science and business. At the same time, we conduct research on methodologies for solving challenging problems that are difficult to address by AI or humans alone, by combining AI with human power.

[Hisashi Kashima , Koh Takeuchi , Kyohei Atarashi ]



**Outline**

**Symbol Emergence Systems**

*Pursuing AI and robots that can act based on understanding the meaning of language in the real world*

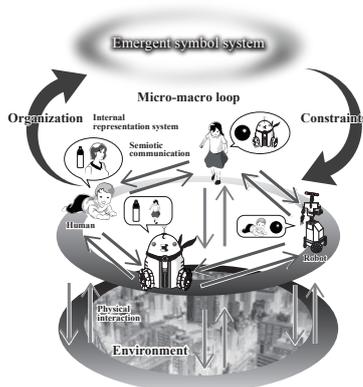
Humans adapt in real-world environments and behave intellectually using their bodies. The language used by humans and the conversations based on that language are, in that sense, intellectual functions we, as part of society, have acquired as a result of evolution and development. This group conducts a wide range of research using theory-based computer experiments, simulations, and robotics, with the

view that the emergence of language and symbols based on real-world cognition forms the core of intelligence. Research topics include symbol emergence in robotics, communication emergence, multimodal linguistic understanding, cognitive architecture, and systems that include humans. The aim of our research is to create AI and robots that coexist with humans.

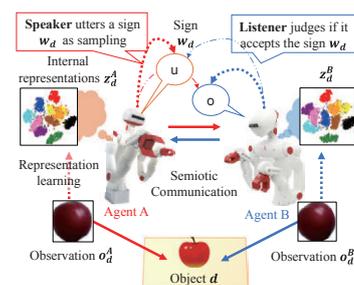
[Tadahiro Taniguchi , Masatoshi Nagano]



Robotics based on a world model and free energy principle and multimodal linguistic understanding



Symbol emergence systems that include people and AI

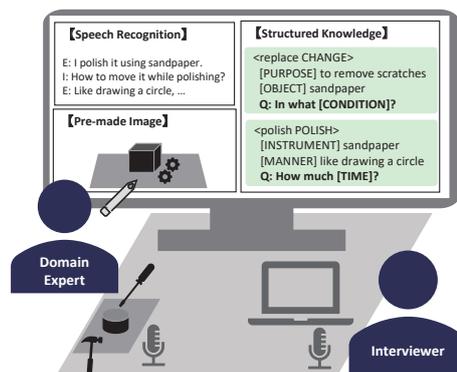


Synthesis of communication emergence and understanding and utilization of large-scale language models

**Language Media Processing**

*Making computers that can understand language*

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



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

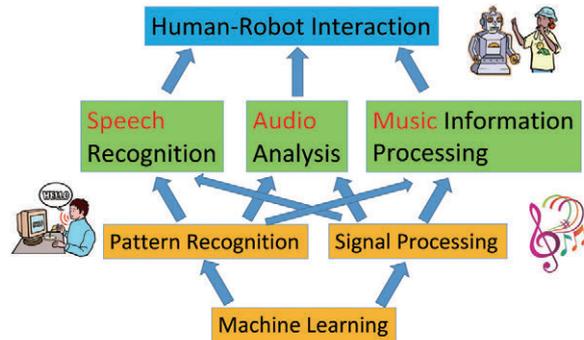
## Speech and Audio Processing

*Recognition and understanding of speech, audio and music*

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

[Tatsuya Kawahara , Keisuke Imoto , Koji Inoue , Keiko Ochi ]

Overview of Speech and Audio Processing Lab.



## Computer Vision

*Making Computers See*

Neural substrates dedicated to vision are said to occupy about 40 percent of the cerebral cortex. Realizing computer vision as a truly intelligent perceptual modality is fundamental for artificial intelligence, and would also inform our understanding of human visual intelligence. Towards computational visual intelligence, our research is focused on establishing the

theoretical foundations and efficient implementations of computational methods for better understanding people, objects and scenes from their appearance in images and video, as well as the development of novel computational imaging systems that can see beyond what we see.

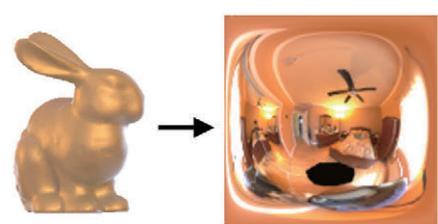
[Ko Nishino , Ken Sakurada , Ryo Kawahara]



Pointing Estimation



Human Body Reconstruction



Illumination and Reflectance Estimation

**Outline**

**Human Sensing**

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

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

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

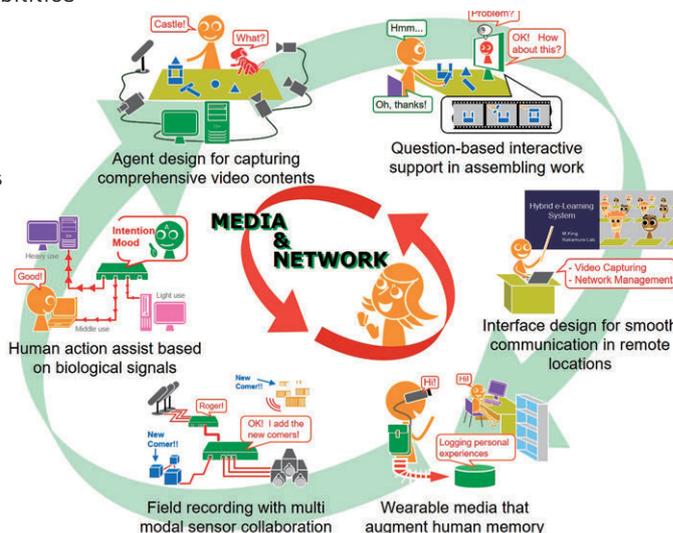
A common approach in all of these media is that information or mechanical systems notice human's intention and augment their abilities

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

[Yuichi Nakamura , Kazuaki Kondo, Kei Shimonishi]

for meeting what they want to do.

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



**Text Media**

*Speech and Natural Language Processing for Multi-media Archives*

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

speech.

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

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

[Shinsuke Mori , Hirotaaka Kameko]

**Language Understanding / Generation**

**Procedural text**

1. 両手で輪を巻く。セリフと手順書とリンクを追加。
2. 別室で待つ。
3. フライパンの水をマカロニと一緒に加熱し、火の弱めから強くなるまで煮る。
4. 鶏むね肉を切る。

**Flow graph** (Mori, LREC14)

**Intelligent search** (Tanaka, Sochi13)

**Smart kitchen** (Hashimoto, SPURT08)

**Culinary** (Then add it)

**Cooking robot** (Hattori, ISRI13)

**Commentary on Computer's Thought**

There is a check mate by SpP.

1. Board recognition by computer vision
2. Symbol grounding by deep learning
3. Automatic generation of language expression

- Collaborating with Univ. of Tokyo

**Language Knowledge Acquisition from Big Data**

- Keyboard logs
- TV programs

World's first statistical agent method

iPS cells, induced pluripotent stem cells

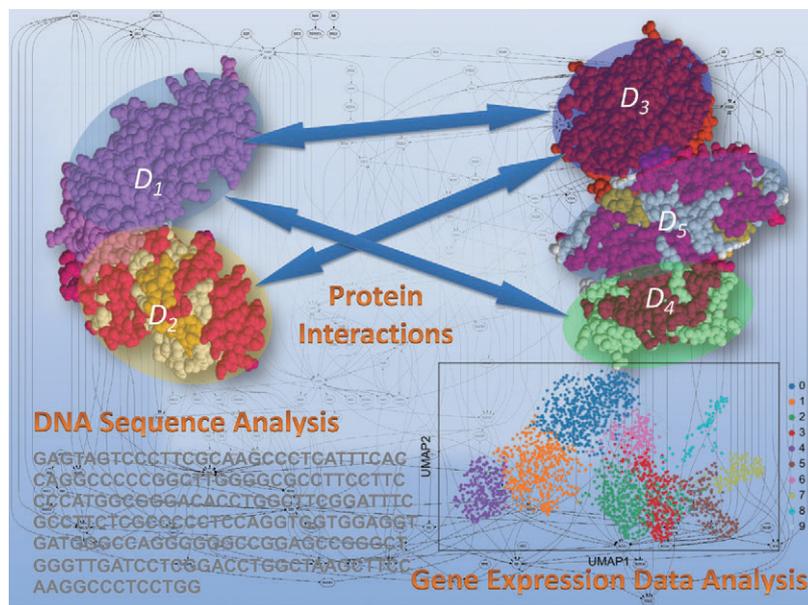
Learn pronunciation from speech

## Biological Information Networks

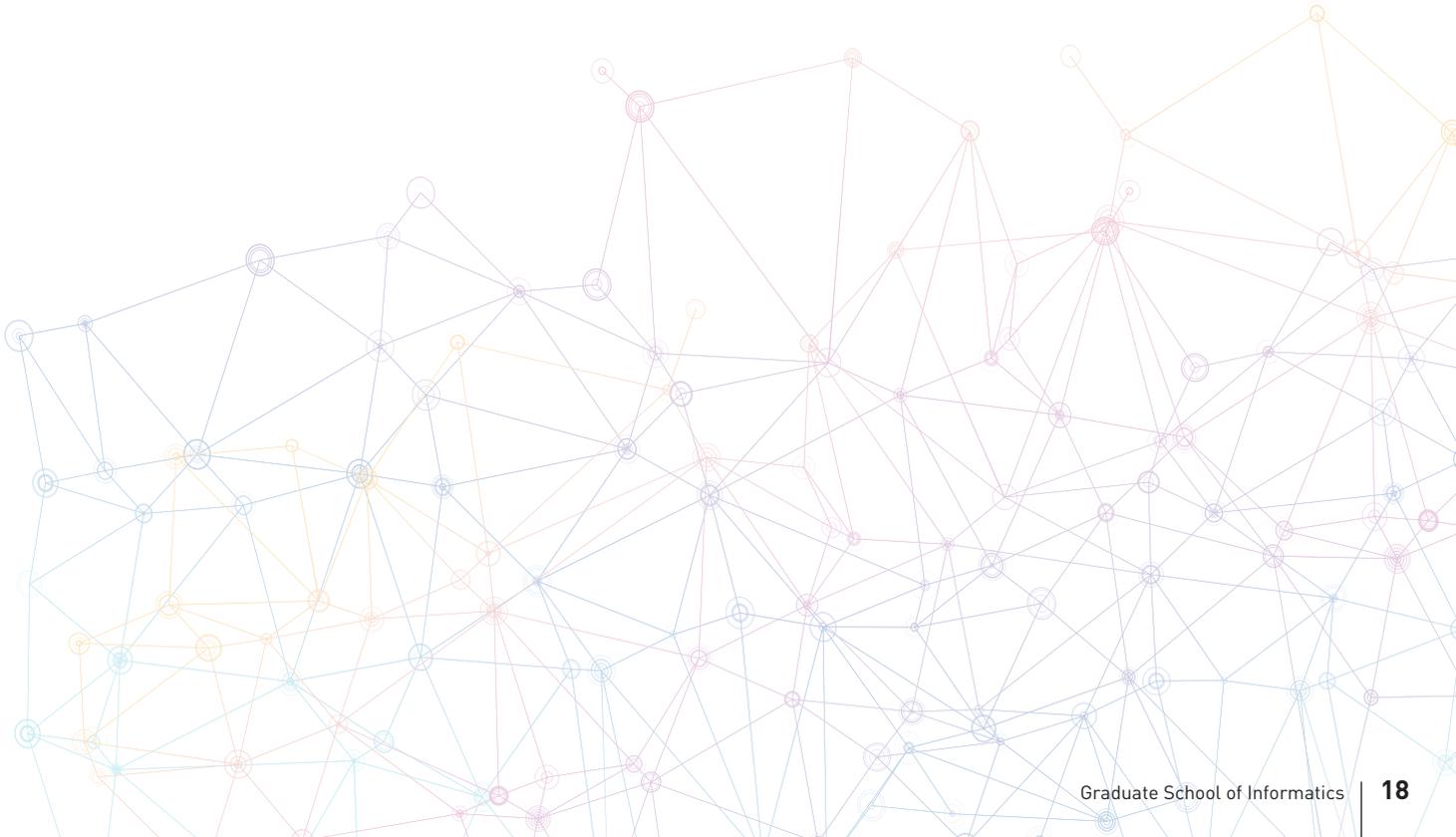
*It for analysis of biological information*

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

[Tatsuya Akutsu , Takeyuki Tamura , Motomu Matsui]



Analysis of three-dimensional structures and interactions of protein

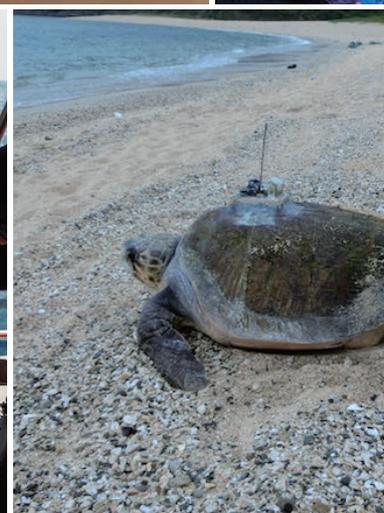


## Harmonizing Society and Information Technology

Global networking is rapidly expanding via information technology.

Based upon the trends of technologies that interact with our daily lives, Social Informatics Course seeks to clarify the structures of highly complex information societies and actually design information systems that are globally useful.

Therefore, we endeavor to support globalizing activities in the areas of culture, economics, ecology, disaster management, healthcare and education.



## Information is Born in the Lives of People

Sources of social information do not exist on the Internet.

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



### *Nobuhito Ohte*

*Professor, Social Informatics Course*

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



## Applications of Information Technologies Expanding

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



### *Takayuki Kanda*

*Social Informatics Course*

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



## Outline

## Group and Teaching Staff

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

## Curriculum of Social Informatics Course

Doctoral Program (Informatics)					
3 <sup>rd</sup>	Doctoral Thesis				
2 <sup>nd</sup>	<b>Subjects provided by the Course (total 6 credits including 4 credits from seminars)</b> Seminar on Social Informatics, Adv.E (Mandatory, 2 credits) Seminar on Social Information Model, Advanced A, B E Seminar on Biosphere Informatics, Advanced A, B E Seminar on Medical Informatics, Advanced A, B E Seminar on Social Information Network, Advanced A, B E Seminar on Regional Disaster Prevention Information Systems, Advanced A, B E Seminar on Social Informatics Analytics Infrastructure, Advanced A, B E (2 credits each)	<b>Research Guidance</b>			
1 <sup>st</sup>					
Master's Program (Informatics)					
2 <sup>nd</sup>	Master's Thesis				
1 <sup>st</sup>	<b>Subjects provided by the Course (6 credits from basic subjects, and optional 4 credits or more from subjects other than basic subjects)</b> <b>Advanced Subjects (2 credits each; except for FBL/PBL1 &amp; 2, which are 1 credit each)</b> Multiagent Systems, Human-Robot Interaction E, Biosphere Informatics E, Disaster Information Emergency Management, Medical Informatics, Informatics of E-business, Information Education Distributed Systems E, Cryptography and Information Society, User Experience (UX) E, Service Modeling Field based Learning/Problem based Learning (FBL/PBL) 1, 2	<b>Seminars and exercises for Master's Thesis (Mandatory 10 credits)</b>  Advanced Study in Social Informatics 2 E (Assigned to M2, 5 credits)  Advanced Study in Social Informatics 1 E (Assigned to M1, 5 credits)			
	<b>Basic Subjects (Assigned to M1, 2 credits each)</b> Information and Society E, Information System Analysis E, Practice of Information Systems E				
	<b>General Subjects provided by the School</b> <b>Interdisciplinary Subjects of the Perspectives in Informatics (Mandatory 2 credits)</b> Perspectives in Informatics 1, Perspectives in Informatics 2 Perspectives in Informatics 3E, Perspectives in Informatics 4E Perspectives in Informatics 5E (2 credits each)	Perspectives in Platform Studies (2 credits), Computational Science, Introduction (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credits), Information Analysis and Management, Exercise (1 credit), Social Contributions through Informatics E (1 credit) Internship in the Field of Informatics E (1 credit)			
<b>Prior to admission</b>	Fundamental background of the subjects in the Course, etc.	Preferred to understand the subjects on the right	Data structure and Algorithms	Fundamental Programming	Fundamental concepts of Computational

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

## Human-Robot Interaction

### *Intelligent robotics for our daily social environments*

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



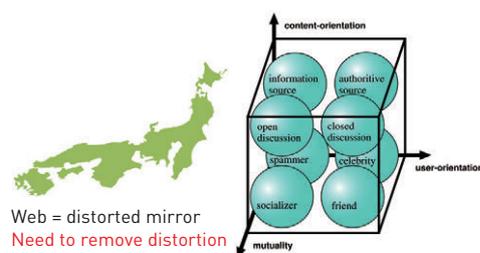
[Takayuki Kanda , Dražen Brščić , Jani Even , Stela H. Seo , Kanae Kochigami]

## Social Media

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

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

[Keishi Tajima]



Web = distorted mirror  
Need to remove distortion

Extraction of social information from the Web

Example of Twitter follow link classification

Internet = Biased reflection of society  
Technology is needed to correct bias

## Outline

## Inclusive Design

### *Toward an inclusive future society*

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

The research topics addressed include:

- Basic communication technologies that foster deeper human relations
- Technologies to detect signs of and intervene in new social problems resulting from the spread of AI
- Design and impact of AI agents that integrated in society
- Information technologies for the realization of inclusive societies

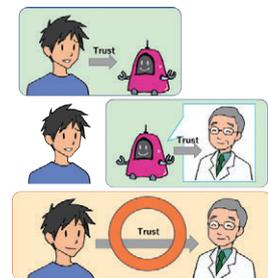
[ Naomi Yamashita ]



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



Support for non-native speakers in multilingual projects



Dialogue agents fostering person-to-person trust

## Consensus Informatics

### *Toward AI-powered Collective Intelligence*

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

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

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

Our interest lies in AI-powered collective intelligence, whereby people and computers or AI agents interact to form consensus and cooperate with each other. Recent research has shown that human collective intelligence is superior to

individual intelligence. Adding highly networked computers and AI to a human population therefore has the potential to achieve higher levels of intelligence on a large scale and with great efficiency. Spectacular advances in AI technology in recent years, typified by large-scale language models, have enabled AI agents with dramatically improved accuracy. So, by getting these AI agents and humans to build consensus and cooperate with each other, we hope to demonstrate an unprecedented degree of collective intelligence, with the ultimate goal of shaping totally new social systems. Our research in this field is focused on AI and multi-agent AI, including support for consensus formation, computational mechanism design, automated negotiating agents, large-scale language models, distributed reinforcement learning, service computing, IoT, argumentation theory, and social simulation.

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

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



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

Over 40 foreign students are enrolled in the Course of Social Informatics, representing more than 15 countries. You may obtain a sense of global community by studying in such a diverse environment. Many students from the Course of Social Informatics make

presentations, discuss research, and join internship programs abroad. A welcome party is held in October to welcome newcomers from foreign countries, and various kinds of international exchanges happen on a daily basis.



An international event

Research presentation at an international conference (Canada)

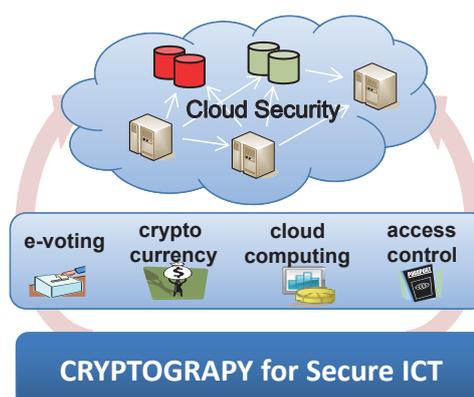
## Information Security (Adjunct Unit)

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

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

key cryptosystems, crypto currency, electronic voting, and other applications suitable for cloud computing with rigorous security analysis based on a firm theoretical foundation.

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



## Outline

## Bioresource Informatics

### *Seeking utilization and conservation of bioresources*

Our research and education efforts are directed at a wide range of subjects to do with the extraction, analysis, and utilization of information, in connection to the use and conservation of terrestrial and marine biological resources. We are particularly focused on developing biologging, biotelemetry, and

environmental DNA methods for collecting bioresource information, and tackling various basic and applied hypotheses related to bioresources, biology, and ecology using big data in the form of geographic information, satellite information, and large databases.

[Hideyuki Doi , Hideaki Nishizawa , Satsuki Tsuji]



Various methods and techniques are applied

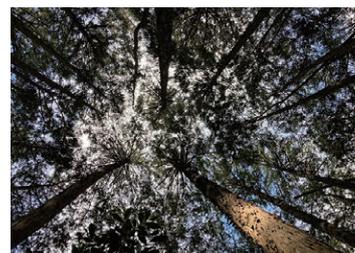
## Environmental Informatics

### *Seeking conservation and utilization of ecosystems*

Recently, society has been interested in environmental changes at various spatial/temporal scales. This group works on topics such as understanding/monitoring environmental information or the role of various organisms in ecosystems. Our research interests cover various fields related to terrestrial ecosystems, ranging from their diverse inhabitants such as plants, animals and microbes to their complete physical environment. We study how these relate to other

organisms or environments in the ecosystems, or how human society influences them with respect to their sustainability in a changing environment. Various methods/approaches such as field investigation, questionnaires, remote-sensing or chemical/isotopic analyses are applied to collect and analyze key information about these ecosystems and organisms.

[Nobuhito Ohte , Lina A. Koyama]



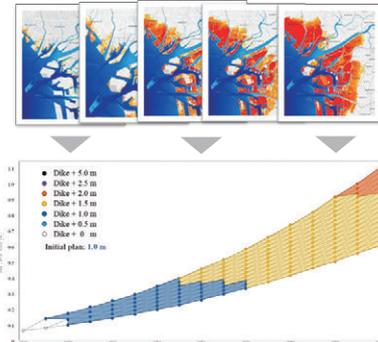
Fieldwork is conducted in various types of sites

## Integrated Disaster Management Systems

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

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

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



Optimal plan to raise embankments in consideration of changes in high tide risks caused by climate change

## 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 risk information and communication, disaster education, regional crisis management and decision making support, and international disaster management assistance.

[Katsuya Yamori , Genta Nakano]



Disaster education materials developed in our lab

## Crisis Information Management System

*Disaster Information Systems with Information Technology*

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

[Michinori Hatayama , Kei Hiroi]



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

Outline

## Medical Informatics

*Exploring approaches to medicine in the information age*

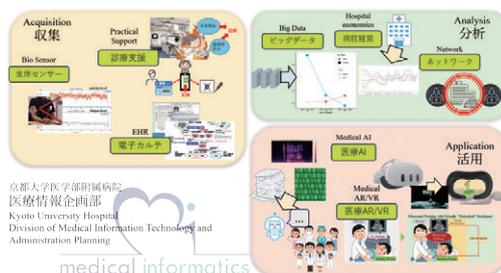
The Medical Informatics Laboratory seeks to create a new vision for medicine in the information age by developing information platforms, analyzing real-life clinical information, and providing feasible information support for existing clinical entities. Our research covers all areas at the interface of information and medicine, including the following:

Collection: development of systems for electronic health records, ubiquitous computing, and biosensors

Analysis: hospital administration analysis based on clinical information, clinical epidemiological

information analysis, and health economic analysis utilizing big data databases

Utilization: VR/AR-based medical education, clinical decision and surgery support, examination and treatment, and development of medical AI that utilizes sensor data



[Tomohiro Kuroda , Yukiko Mori , Akira Yutani , Kazumasa Kishimoto]

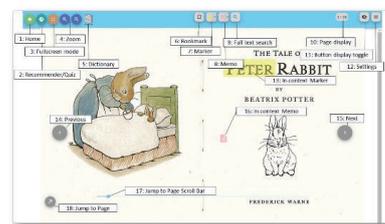
## Learning and Educational Technologies

*Information Systems that Support Learning and Education*

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

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

[Hiroaki Ogata , John Brendan Flanagan]



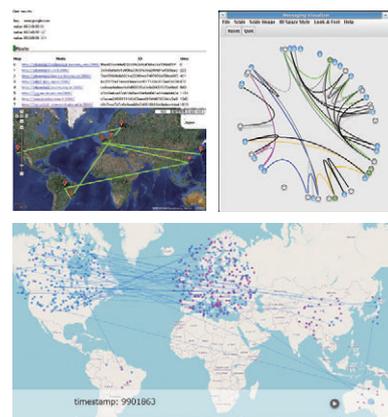
Example of a learning analytics system (LEAF/BookRoll/LogPallet)

## Data Engineering and Platform Research

*Research in support of internet-scale data infrastructure*

This laboratory researches technology for handling big data such as algorithm and simulation technologies for decentralized-distributed systems, cloud technologies for computer clusters that handle big data, network technology and cybersecurity to support the distribution of big data, and internet and social media big data analysis technology. Specific topics include:

- Internet and social media big data analysis
- Computer cluster structure technology for cloud computing
- Access control technology to achieve Zero Trust
- Cybersecurity



[Kazuyuki Shudo , Daisuke Kotani , Shiori Hironaka ]

# Special Education Program of Social Informatics Course

## 1. Specialized Subjects and special Lecture



Special lecture

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

## 2. Education for Innovation

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

The Course of Social Informatics joins Kyoto University Design School, in which students take a course titled "FBL (Field based Learning)/ PBL (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 course of Social Informatics, and has become a seasonal tradition in summer, attracting more than 250 participants to share the same innovative space. Over 20 different kinds of themes were proposed by companies and universities, and were tackled by many students eager to solve real-world problems: they went into the field, and used trial-and-error methods by actually creating prototypes. The Course of Social Informatics proposed themes such as "Predicting Kyoto in 2050 by simulation" and "Designing safety into apartment buildings: first priority, disaster prevention".

## 3. Education for Globalization



Strategic communication seminar

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

# Mathematical Modeling and Analysis of Phenomena

— In Pursuit of Introduction of Science and Engineering —

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

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

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

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

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

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

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



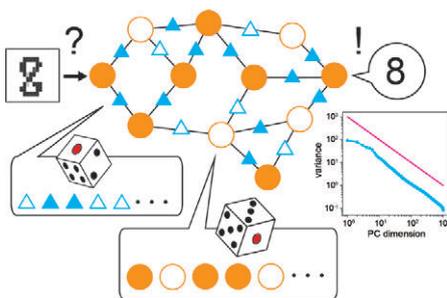
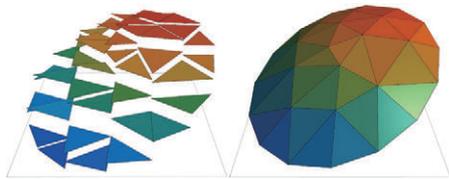
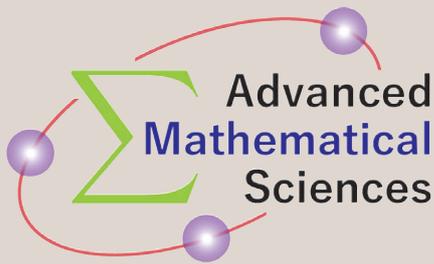
## An Invitation to Mathematical Sciences

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

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

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

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



### *Hiroshi Fujiwara*

*Professor, Advanced Mathematical Sciences Course*

Professor Fujiwara obtained his B.S. degree from Kyoto University in 1999, and Ph.D. from Kyoto University in Informatics in 2003. His research themes are numerical analysis for partial differential equations, inverse and ill-posed problems, and design and implementation of numerical software.

## Outline

### ■ Laboratory and Teaching Staff

Laboratory	Teaching Staff
<b>Applied Analysis</b>	Jun Kigami/Professor Daisuke Shiraishi/Associate Professor Masayoshi Kubo/Assistant Professor Ryosuke Shimizu/Assistant Professor
<b>Nonlinear Physics (Nonlinear Dynamics and Computational Statistical Physics)</b>	Syuji Miyazaki/Senior Lecturer Kenji Harada/Assistant Professor
<b>Nonlinear Physics (Non-equilibrium Physics and Theoretical Neuroscience)</b>	Toshio Aoyagi/Professor Jun-nosuke Teramae/Associate Professor Hiroki Tutu/Assistant Professor
<b>Computational Mechanics</b>	Hiroshi Fujiwara/Professor Daisuke Kawagoe/Assistant Professor
<b>Industrial Mathematics</b>	Satoshi Taguchi/Professor Tetsuro Tsuji/Associate Professor
<b>Statistical Signal Processing</b>	Kazunori Hayashi/Professor (Secondary appointment : Institute of Liberal Arts and Sciences)

### ■ Curriculum of Advanced Mathematical Sciences Course

Doctoral Program (Informatics)			
<b>3<sup>rd</sup></b>	Doctoral Thesis		
<b>2<sup>nd</sup></b>	Subjects provided by the Course (total 6 credits) Seminar on Mathematical Sciences (Advanced) <i>E</i> (2 credits Mandatory)		<b>Research Guidance</b>
<b>1<sup>st</sup></b>	Seminar on Applied Analysis (Advanced A & B) <i>E</i> (2 credits each), Seminar on Nonlinear Physics (Advanced A & B) <i>E</i> (2 credits each), Seminar on Applied Mathematical Sciences (Advanced A & B) <i>E</i> (2 credits each)		
Master's Program (Informatics)			
Master's Thesis			
<b>2<sup>nd</sup></b>	Subjects provided by the Course (Optional 8 credits or more) <b>Advanced Subjects (A and B are offered every other year)</b> Topics in Differential Equations A,B (2 credits each), Topics in Nonlinear Analysis A,B (2 credits each), Topics in Applied Analysis I, II (1 credit each), Topics in Nonlinear Dynamics A,B (2 credits each), Topics in Nonequilibrium Physics A,B (2 credits each), Topics in Nonlinear Physics I, II (1 credit each), Topics in Computational Mechanics A,B (2 credits each), Topics in Mathematical Sciences A,B (2 credits each), Topics in Applied Mathematical Sciences I, II (1 credit each)	<b>Seminar Subjects</b> Seminar on Applied Analysis II Seminar in Nonlinear Physics II Seminar in Applied Mathematical Sciences II (Those planning to proceed to doctoral program: Assigned to M2, 4 credits each) Seminar on Applied Analysis I Seminar in Nonlinear Physics I Seminar in Applied Mathematical Sciences I (Assigned to M1, 4 credits each)	Seminars and exercises for Master's thesis (Mandatory 8 credits)  Advanced Study in Mathematical Sciences 2 (Assigned to M2, 6 credits)  Advanced Study in Mathematical Sciences 1 (Assigned to M1, 2 credits)
<b>1<sup>st</sup></b>	General Subjects provided by the School (Compulsory elective 2 or more credits and 4 credits or less for ◎ subjects) <b>Interdisciplinary Subjects of the Perspectives in Informatics</b> ◎Perspectives in Informatics 1 ◎Perspectives in Informatics 2 ◎Perspectives in Informatics 3 ◎Perspectives in Informatics 4 ◎Perspectives in Informatics 5 (2 credits each)	◎Perspectives in Platform Studies (2 credits), Computational Science, Introduction(2 credits), Computational Science, Exercise A (1 credits), ◎Information and Intellectual Property(2 credits), Innovation and Information(2 credits), Information Analysis and Management(2 credits), Information Analysis and Management, Exercise (1 credits), Social Contributions through Informatics(1 credits), Internship in the Field of Informatics (1 credits),	<b>Specific subjects provided by the school</b>
<b>Prior to admission</b>	Calculus	Linear Algebra	Fundamentals of Ordinary Differential Equations
			Fundamentals of Complex Analysis
			Mechanics of Particles, Systems of Particles, and Rigid Bodies
			Academic Foundations at Undergraduate Level for Study at the Course

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

## Admission, Curriculum and Other Efforts in Our Course

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

Our curriculum for the Master course consists of both general and specialized subjects. All students are advised to take three general subjects, which help them to develop both scientific and engineering perspectives in mathematical sciences. Research

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

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



## Applied Analysis Laboratory

### *Analysis in the 21st Century*

#### ■ Fractal Analysis, Fractal Geometry

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

[Jun Kigami]

#### ■ Structure of Brownian Motion and Random Walk

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

[Daisuke Shiraishi]

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

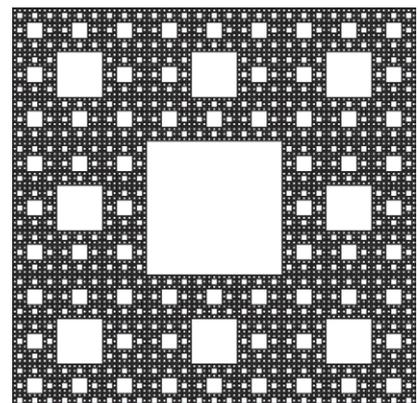
I mathematically analyze partial differential equations that appear in mathematical physics and mathematically and numerically analyze the inverse problems found in these partial differential equations, where the unknown coefficients of these inverse problems are determined by observed data.

[Masayoshi Kubo]

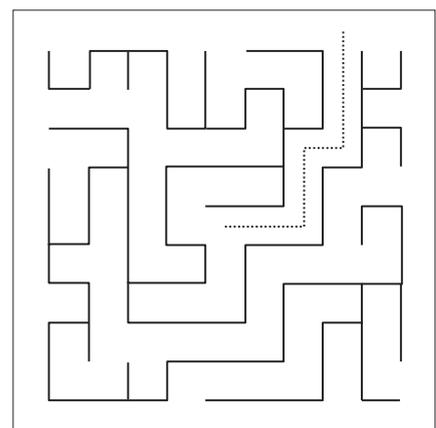
#### ■ Analysis and geometry of fractals and metric spaces

Aiming to address problems that have been identified in the study of metric space geometry, I research basic theories in analysis such as nonlinear potential theory on complex spaces including fractals. Specifically, I aim to shed light on the relationship with quasiconformal geometry and on phenomena unique to fractals that cannot occur with a classic approach.

[Ryosuke Shimizu]



Sierpiński carpet



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

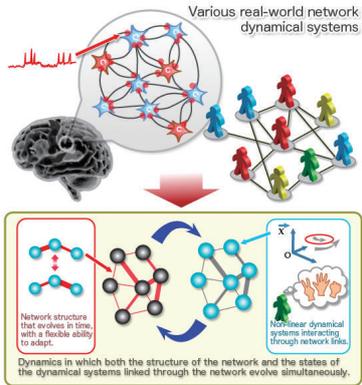
**Outline**

**Nonlinear Physics Laboratory**

**Group of Non-equilibrium Physics and Theoretical Neuroscience**

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

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

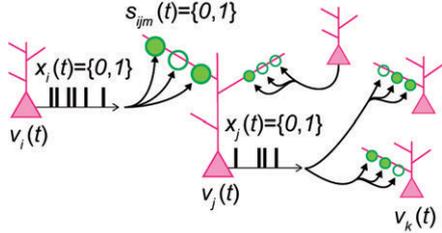


Neural systems and social networks are nonlinear dynamic systems that have a high degree of freedom and develop as their dynamic elements change the structure of their interconnections.

**Nonlinear physics of computation and learning in the brain**

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

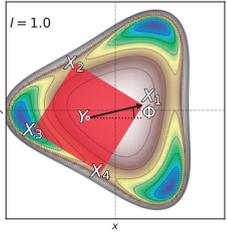
What is intelligence? What is underlying principles of neural computation and learning? Our recent study, for example, reveals significant roles of spontaneous fluctuation in neural computation. By integrating neuroscience, computer science, and nonlinear physics, here we are trying to answer these questions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



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

**Mathematical models for molecular machines**

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

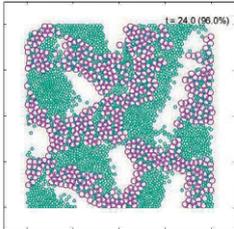


Rotary ratchet model consisting of a rotor (rigid body consisting of four points) and a rotor housing (potential) that simulates a Wankel rotary engine

**Group of Nonlinear Dynamics and Computational Statistical Physics**

**Study on powders and charged particles under cyclic external forces**

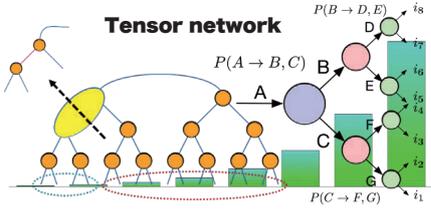
Inspired by experiments in which several micron-size charged corpuscles are injected into an AC trap, a simplified version of a Paul ion trap, and prior studies into the particle model of ion channels and its anomalous transport, we mainly study collective motions of granular materials and charged corpuscles,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



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

**Statistical physics using computational approaches**

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



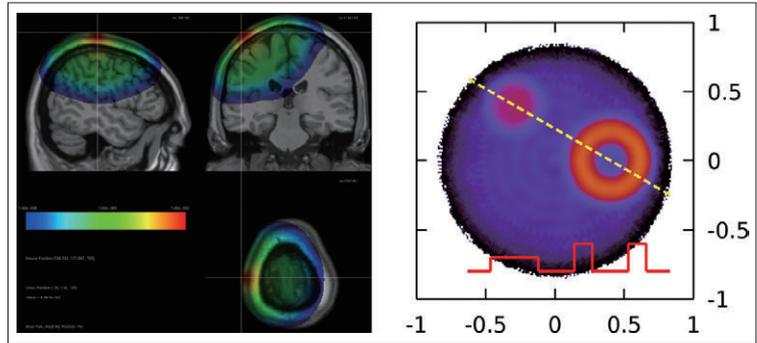
Researchers actively study new compression methods for large data sets and deep learning models with exponentially growing parameters using tensor network representation.

## Computational Mechanics Laboratory

*Computer simulations: development of highly reliable numerical analysis methods and their applications to inverse problems*

The understanding of phenomena with mathematical models is applied to a wide range of scientific and technological advancements. This lab analyzes inverse problems in topics such as the development of numerical computation methods and medical imaging to understand and apply phenomena described in partial differential equations and integral equations. Specifically, we specialize in analysis of numerical computation methods, multiple-precision computation, massively parallel computation, and numerical analysis to shed light on the properties of mathematical models.

[Hiroshi Fujiwara, Daisuke Kawagoe]



Simulation of light propagation in an organism (left) and example of identification of optical properties (right)

## Industrial Mathematics Laboratory

*Toward new fluid mechanics for non-equilibrium flows*

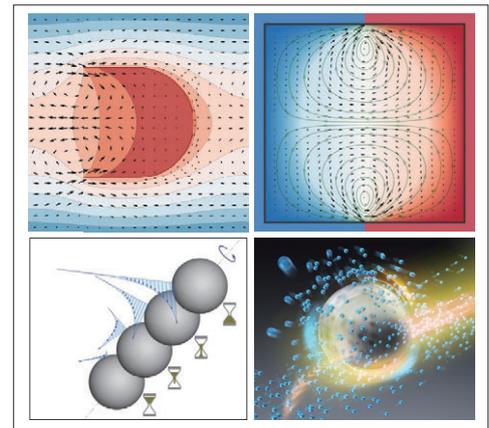
In our group we investigate the behavior of non-equilibrium flows based on kinetic theory describing the collective behavior of innumerable particles.

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

[Satoshi Taguchi]

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

[Tetsuro Tsuji]



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

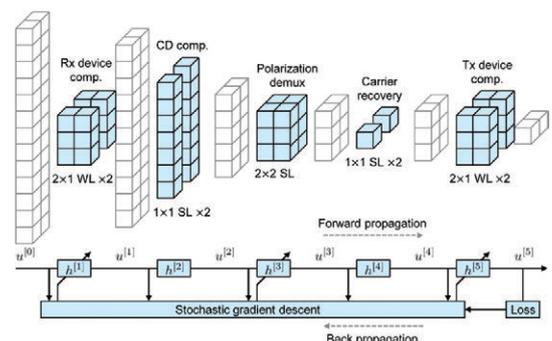
## Statistical Signal Processing Laboratory

*Integration of Model-based and Data-driven Approaches*

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

[Kazunori Hayashi]

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

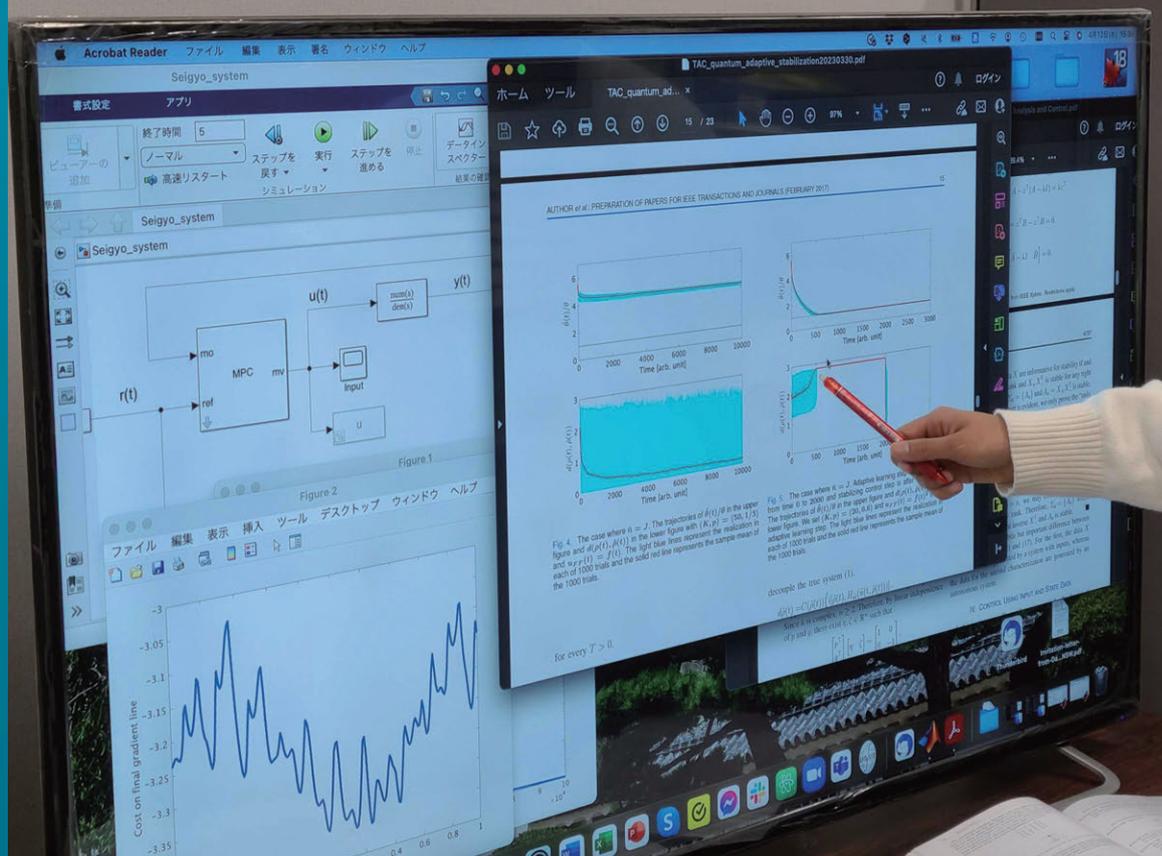


## Using Applied Mathematics and Physics to Seek Solutions to Problems in Engineering/ Natural Systems

In the highly advanced information society of today, we encounter various situations that involve modeling and analysis of complex and large-scale systems, their control, design, and operation.

In these situations, it is extremely important to uncover common mathematical structures shared by those problems which are seemingly unrelated, and to develop mathematical methods to solve them, in addition to acquiring specialized knowledge of individual disciplines such as information technology, electricity, mechanics, and chemistry.

From this viewpoint, the seven laboratories of the Course of Applied Mathematics and Physics undertake leading-edge research on applied mathematical analysis, discrete mathematics, system optimization, control systems theory, applied mathematical modeling (adjunct unit), physical statistics, and dynamical system theory.



## Universality of the Power law and Establishing Risk Indicators

### *The discovery and application of a super generalized central limit theorem*

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



### *Ken Umeno*

*Professor, Applied Mathematics and Physics Course*

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

## Mathematics and Computers for Solving Problems through Optimization

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

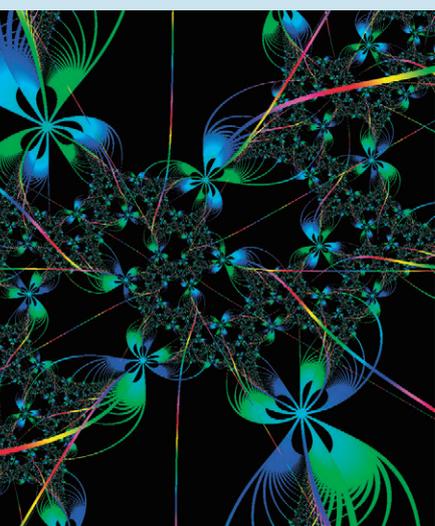
Our laboratory deals mainly with continuous optimization, in which the candidate optimal solutions are expressed as continuous variables. Continuous optimization is an essential tool for deep learning and financial engineering. Why not come along and take advantage of the power of applied mathematics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



### *Nobuo Yamashita*

*Professor, Applied Mathematics and Physics Course*

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



## Outline

### Group and Teaching Staff

Group	Teaching Staff
<b>Applied Mathematical Analysis</b>	Satoshi Tsujimoto/Professor Katsuki Kobayashi/Assistant Professor
<b>Discrete Mathematics</b>	Kazuya Haraguchi/Associate Professor Kanae Yoshiwatari/Assistant Professor
<b>System Optimization</b>	Nobuo Yamashita/Professor Ellen Hidemi Fukuda/Associate Professor
<b>Control Systems Theory</b>	Kenji Kashima/Professor Kentaro Ohki/Assistant Professor
<b>Physical Statistics</b>	Ken Umeno/Professor Erica Uehara/Senior Lecturer Hajime Koike/Assistant Professor
<b>Dynamical Systems</b>	Mitsuru Shibayama/Associate Professor Yoshiyuki Yamaguchi/Assistant Professor
<b>Applied Mathematical Modeling (Adjunct Unit)</b>	Yoichi Nonaka/Adjunct Professor Yoshiyasu Takahashi/Adjunct Associate Professor (Hitachi Ltd.)

### Curriculum of Applied Mathematics and Physics Course

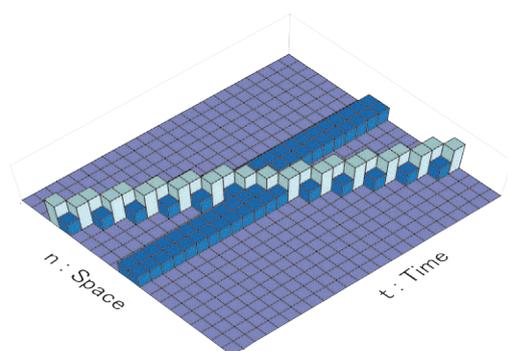
Doctoral Program (Informatics)			
3 <sup>rd</sup>	Doctoral Thesis		
2 <sup>nd</sup>	<b>Subjects provided by the Course (total 6 credits including 4 credits from seminars)</b> Seminar on Applied Mathematics and Physics, Advanced A, B, E (2 credits) Seminar on Applied Mathematics, Advanced, E Seminar on Applied Mathematical Systems, Advanced, E Seminar on Mathematical Physics, Advanced, E (2 credits each)		
1 <sup>st</sup>		Research Guidance	
Master's Program (Informatics)			
Master's Thesis			
2 <sup>nd</sup>	<b>Subjects provided by the Course</b> (Optional 12 credits or more from the recommended subjects provided by the other Course. 8 or more credits are required from the subjects provided by the Course and "Computational Science, Introduction" of the general subject provided by the School.)		
	<table border="1"> <tr> <td> <b>Advanced Subjects</b>                      Mathematical Analysis, Adv., Discrete Mathematics, Adv., Control Systems Theory, Adv., Optimization Theory, Adv., Physical Statistics, Adv., Dynamical Systems, Adv. (2 credits each)                      Financial Engineering, Topics in Applied Mathematics and Physics A (1 credit each)                      Topics in Applied Mathematics and Physics B (1 credit each)                 </td> <td> <b>Seminar Subjects</b>                      Seminar in Mathematical Analysis, Seminar in Discrete Mathematics, Seminar in System Optimization, Seminar in Control Systems Theory Seminar in Physical Statistics, Seminar in Dynamical Systems  <b>Recommended Subjects provided by other Courses</b>                      Pattern Recognition Adv. E (IST), other 11 subjects                 </td> </tr> </table>	<b>Advanced Subjects</b> Mathematical Analysis, Adv., Discrete Mathematics, Adv., Control Systems Theory, Adv., Optimization Theory, Adv., Physical Statistics, Adv., Dynamical Systems, Adv. (2 credits each) Financial Engineering, Topics in Applied Mathematics and Physics A (1 credit each) Topics in Applied Mathematics and Physics B (1 credit each)	<b>Seminar Subjects</b> Seminar in Mathematical Analysis, Seminar in Discrete Mathematics, Seminar in System Optimization, Seminar in Control Systems Theory Seminar in Physical Statistics, Seminar in Dynamical Systems <b>Recommended Subjects provided by other Courses</b> Pattern Recognition Adv. E (IST), other 11 subjects
<b>Advanced Subjects</b> Mathematical Analysis, Adv., Discrete Mathematics, Adv., Control Systems Theory, Adv., Optimization Theory, Adv., Physical Statistics, Adv., Dynamical Systems, Adv. (2 credits each) Financial Engineering, Topics in Applied Mathematics and Physics A (1 credit each) Topics in Applied Mathematics and Physics B (1 credit each)	<b>Seminar Subjects</b> Seminar in Mathematical Analysis, Seminar in Discrete Mathematics, Seminar in System Optimization, Seminar in Control Systems Theory Seminar in Physical Statistics, Seminar in Dynamical Systems <b>Recommended Subjects provided by other Courses</b> Pattern Recognition Adv. E (IST), other 11 subjects		
	<b>Seminars and exercises for Master's Thesis (Mandatory 10 credits)</b> Advanced Study in Social Informatics 2E (Assigned to M2, 5 credits) Advanced Study in Social Informatics 1E (Assigned to M1, 5 credits)		
1 <sup>st</sup>	<b>General Subjects provided by the School (2 credits each)</b> <table border="1"> <tr> <td> <b>Interdisciplinary Subjects of the Perspectives in Informatics (Mandatory 2 credits)</b>                      Perspectives in Informatics 1 Perspectives in Informatics 2                      Perspectives in Informatics 3E Perspectives in Informatics 4E                      Perspectives in Informatics 5E (2 credits each)                 </td> <td>                     Perspectives in Platform Studies (2 credits), <u>Computational Science, Introduction</u> (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credits), Information Analysis and Management, Exercise (1 credit) Social Contributions through Informatics E (1 credit) Internship in the Field of Informatics E (1 credit)                 </td> </tr> </table>	<b>Interdisciplinary Subjects of the Perspectives in Informatics (Mandatory 2 credits)</b> Perspectives in Informatics 1 Perspectives in Informatics 2 Perspectives in Informatics 3E Perspectives in Informatics 4E Perspectives in Informatics 5E (2 credits each)	Perspectives in Platform Studies (2 credits), <u>Computational Science, Introduction</u> (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credits), Information Analysis and Management, Exercise (1 credit) Social Contributions through Informatics E (1 credit) Internship in the Field of Informatics E (1 credit)
<b>Interdisciplinary Subjects of the Perspectives in Informatics (Mandatory 2 credits)</b> Perspectives in Informatics 1 Perspectives in Informatics 2 Perspectives in Informatics 3E Perspectives in Informatics 4E Perspectives in Informatics 5E (2 credits each)	Perspectives in Platform Studies (2 credits), <u>Computational Science, Introduction</u> (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credits), Information Analysis and Management, Exercise (1 credit) Social Contributions through Informatics E (1 credit) Internship in the Field of Informatics E (1 credit)		
	Specific subjects provided by the school		
Prior to admission	<b>Basic Mathematics</b> Calculus, Linear algebra, etc.		
Preferred to understand the subjects on the right	<b>Applied Mathematics</b> Complex functions, Fourier analysis, Numerical analysis, Graph theory, etc.		
	<b>Mathematical Systems</b> Linear programming, Optimization, Control theory, etc.		
	<b>Mathematical Physics</b> Classical dynamics, Differential equation, Statistical mechanics, etc.		

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

## Applied Mathematical Analysis

### Developing algorithms from integrable systems

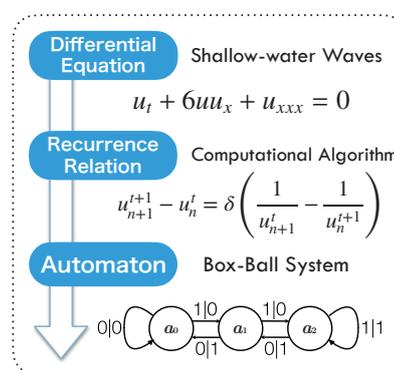
We carry out research in the areas of contemporary soliton research and integrable system research, not only regarding the applied analysis of orthogonal polynomials and special functions that are closely associated with integrable systems, but also regarding the application of the mathematical methods developed by integrable system studies to the solution of various problems hitherto thought to be unrelated to integrable systems



Ultra-discrete soliton

(such as numerical calculation and algorithm development). Our Group is a pioneer in this research field, and conducts studies into the applied analysis of integrable systems in the development of algorithms and other new branches of mathematics from the perspective of computer science.

[Satoshi Tsujimoto, Katsuki Kobayashi]



Theory linking continuous and discrete systems, and automata

## Discrete Mathematics

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

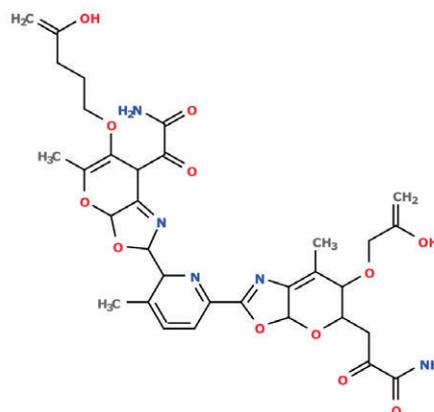
Topics in discrete mathematics, such as the graphs and networks used to represent systems, schedules to enhance the efficiency of production, and the logical analysis of large volumes of data, are closely related to applications of research results. We explore the

complexity of the computation used to solve these problems; design exact and approximation algorithms; develop tabu search algorithms, genetic algorithms and other metaheuristic algorithms; and apply them to solving actual problems.

[Kazuya Haraguchi, Kanae Yoshiwatari]



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.



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

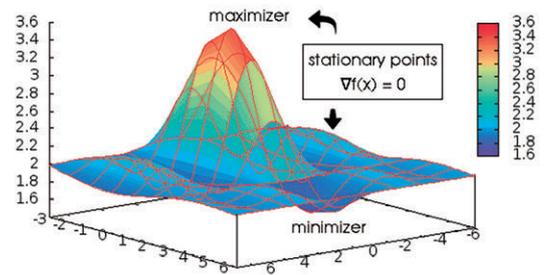
**Outline**

**System Optimization**

*Optimization is the keyword for solving problems*

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

[Nobuo Yamashita , Ellen Hidemi Fukuda]



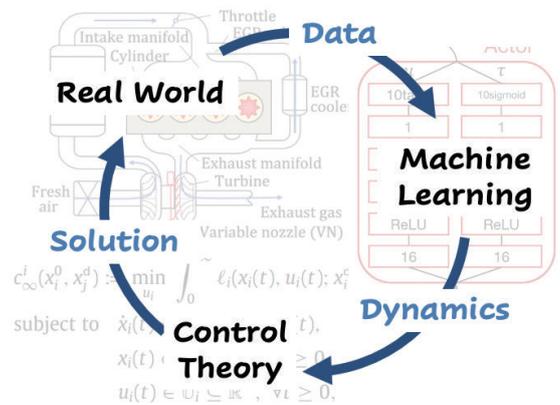
Optimal solutions of an unconstrained problem

**Control Systems theory**

*Mathematical approaches to modeling and control*

We carry out teaching and research on control theory—a mathematical method for analyzing and designing phenomena that change over time—and its application, with an emphasis on its development potential and practicality. In particular, we place emphasis on developing methods that incorporate machine learning. Our main research themes are control of stochastic systems, integration with statistical learning theory, and quantum control theory.

[Kenji Kashima , Kentaro Ohki]



Conceptual diagram of a control system design



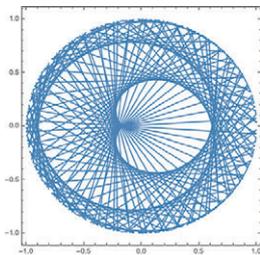
## Physical Statistics

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

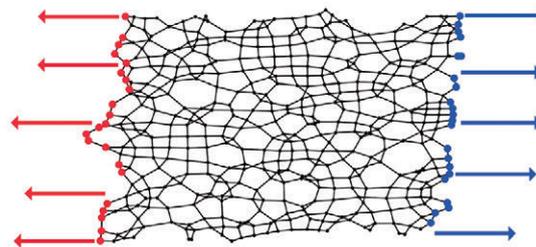
We aim to gain a mathematical and unified understanding of the complex and diverse phenomena that arise out of the intense mutual interactions of multiple elements (units) in a system and apply this understanding to information processing and design of complex engineering systems. For example, we will use stochastic process theory, ergodic theory, statistical physics, dynamical system theory, computer simulations, and large-scale

data processing techniques to analyze information processing and performance evaluation in neural networks; the structure of the Internet and other complex networks such as social media systems, and the propagation of information within them; and the dynamical properties of price change, stock markets and other economic phenomena.

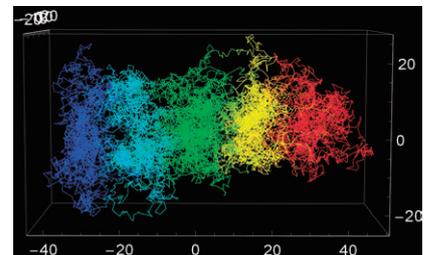
[Ken Umeno , Erica Uehara , Hajime Koike ]



Chaos code for signal analysis and multiuser communications system



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



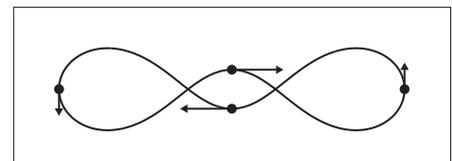
Polymer physics

## Dynamical Systems

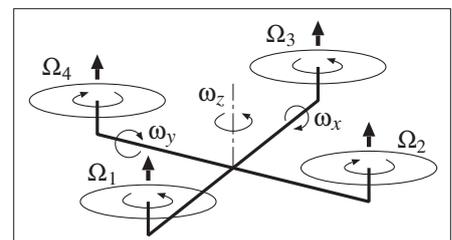
*Looking into the world through dynamical systems theory*

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

[Mitsuru Shibayama , Yoshiyuki Yamaguchi]



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



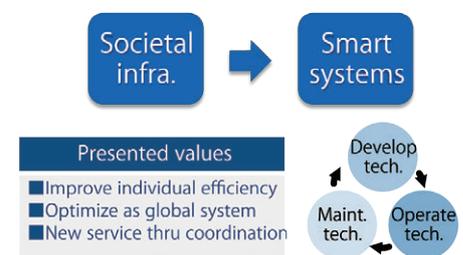
Mathematical model of a quadcopter

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

*Infusing information systems with intelligence*

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

[Hitachi Ltd.: Yoichi Nonaka , Yoshiyasu Takahashi]



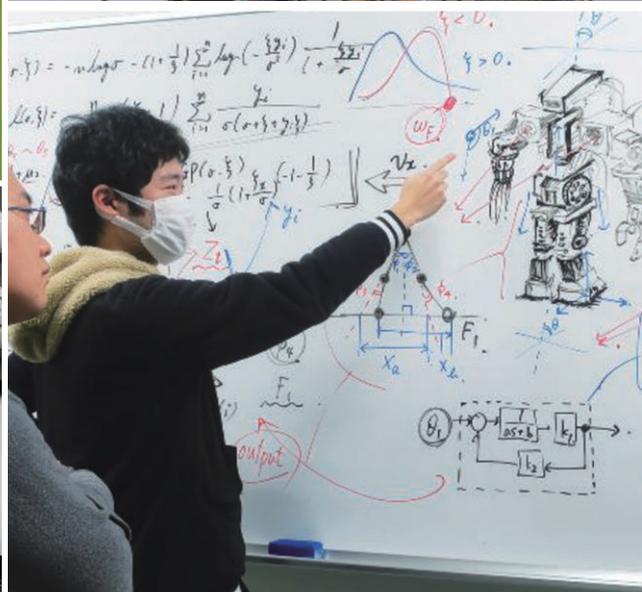
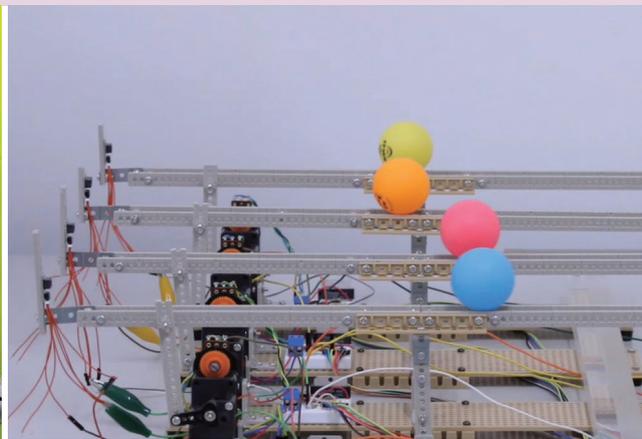
Modeling of a social infrastructure system

## New Frontier in Informatics and Systems

Research and education in the Course of Systems Science are concerned with a new and unified approach to a variety of technological problems arising in computer communication networks, mechatronics systems, cyber-physical systems, medical information systems, and biological systems.

In particular, we are seeking theoretical methodologies applicable to these complex systems of large scales.

Emphasis is also placed upon understanding of complicated mutual interactions among human-beings, systems and environments.



## Putting Information into Action

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

human brain uses the data it obtains for making decisions, and they can learn useful methodologies for understanding and applying such knowledge. The course offers a learning environment for cultivating essential insights for pursuing this kind research.



### Jun Morimoto

*Professor, Systems Science Course*

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

## Learning “How” to Address Unknown Issues

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

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

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

Another characteristic of students/researchers in the Course of Systems Science is strongly conscious of systems in the real world, in addition to conducting mathematical study at an

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

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



### Hidetoshi Shimodaira

*Systems Science Course*

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

## Outline

### Group and Teaching Staff

Group	Teaching Staff
<b>Mechanical Systems Control</b>	Shun-ichi Azuma/Professor Ikumi Banno/Assistant Professor
<b>Human Systems</b>	Manabu Kano/Professor Kana Eguchi/Senior Lecturer Shota Kato/Assistant Professor
<b>Integrated Dynamical Systems</b>	Toshiyuki Ohtsuka/Professor
<b>Mobility Research</b>	Osamu Nishihara/Associate Professor
<b>Mathematical Information Systems</b>	Toshiyuki Tanaka/Professor Tomoyuki Obuchi/Associate Professor
<b>Statistical Intelligence</b>	Hidetoshi Shimodaira/Professor Junya Honda/Associate Professor Hiroaki Yamagiwa/Assistant Professor
<b>Learning Machines</b>	Jun Morimoto/Professor Satoshi Yagi/Assistant Professor Satoshi Yamamori/Program-Specific Assistant Professor
<b>Integrated Systems Biology</b>	Shin Ishii/Professor Hideaki Shimazaki/Associate Professor Risa Katayama/Assistant Professor PHI, Tien Cuong/Program-Specific Assistant Professor GONG, Rui/Program-Specific Assistant Professor
<b>Biocybernetics</b>	Taishin Nomura/Professor
<b>Computational Neuroscience (Adjunct Unit)</b>	Mitsuo Kawato/Adjunct Professor (Advanced Telecommunications Research Institute International) Takuya Isomura/Adjunct Professor Louis Kang/Adjunct Associate Professor (RIKEN) Kenji Doya/Adjunct Professor (Okinawa Institute of Science and Technology)

### Curriculum of Systems Science Course

Doctoral Program (Informatics)					
3 <sup>rd</sup>	Doctoral Thesis				
2 <sup>nd</sup>	<b>Subjects provided by the Course (total 6 credits including 4 credits from seminars)</b> Seminar on Systems Science, Adv. E (2 credits) Seminar on Human Machine Symbiosis, Advanced A, B E, Seminar on Systems Synthesis, Advanced A, B E Seminar on Systems Informatics, Advanced A, B E (2 credits each)				
1 <sup>st</sup>		Research Guidance			
Master's Program (Informatics)					
Master's Thesis					
2 <sup>nd</sup>	<b>Subjects provided by the Course (optional 8 credits or more)</b> <table border="1" style="width: 100%;"> <tr> <td> <b>Advanced Subjects</b>                      Systems Sciences, Advanced II, Control Theory for Mechanical Systems, Theory of Human - Machine Systems, Theory of Integrated Dynamical Systems, Theory of Learning Machines, Integrated Systems Biology, Medical Information Systems, Modeling and Problem-Solving of Complex Systems, Systems Biology E (2 credits each)                      Computational Neuroscience, Computational Intelligence (1 credit each)                 </td> <td> <b>Recommended Subjects by Other Courses</b>                      Information-Theoretic Systems Theory (DS)                      Statistical Systems Theory (DS)                      (2 credits each)                 </td> </tr> <tr> <td> <b>Basic Subjects</b>                      Systems Sciences, Adv. I (2 credits)                 </td> <td></td> </tr> </table>	<b>Advanced Subjects</b> Systems Sciences, Advanced II, Control Theory for Mechanical Systems, Theory of Human - Machine Systems, Theory of Integrated Dynamical Systems, Theory of Learning Machines, Integrated Systems Biology, Medical Information Systems, Modeling and Problem-Solving of Complex Systems, Systems Biology E (2 credits each) Computational Neuroscience, Computational Intelligence (1 credit each)	<b>Recommended Subjects by Other Courses</b> Information-Theoretic Systems Theory (DS) Statistical Systems Theory (DS) (2 credits each)	<b>Basic Subjects</b> Systems Sciences, Adv. I (2 credits)	
<b>Advanced Subjects</b> Systems Sciences, Advanced II, Control Theory for Mechanical Systems, Theory of Human - Machine Systems, Theory of Integrated Dynamical Systems, Theory of Learning Machines, Integrated Systems Biology, Medical Information Systems, Modeling and Problem-Solving of Complex Systems, Systems Biology E (2 credits each) Computational Neuroscience, Computational Intelligence (1 credit each)		<b>Recommended Subjects by Other Courses</b> Information-Theoretic Systems Theory (DS) Statistical Systems Theory (DS) (2 credits each)			
<b>Basic Subjects</b> Systems Sciences, Adv. I (2 credits)					
1 <sup>st</sup>	<b>Seminars and exercises for Master's thesis (Mandatory 10 credits)</b> Advanced Study in System Science 2E (Assigned to M2, 5 credits) Advanced Study in System Science 1E (Assigned to M1, 5 credits)				
<b>General Subjects provided by the School</b> <table border="1" style="width: 100%;"> <tr> <td> <b>Interdisciplinary subjects of the Perspectives in Informatics (Mandatory 2 credits)</b>                      Perspectives in Informatics 1 Perspectives in Informatics 2                      Perspectives in Informatics 3E Perspectives in Informatics 4E                      Perspectives in Informatics 5E (2 credits each)                 </td> <td>                     Perspectives in Platform Studies (2 credits), Computational Science, Introduction (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credit), Information Analysis and Management, Exercise (1 credit), Social Contributions through Informatics E (1 credit), Internship in the Field of Informatics E (1 credit)                 </td> </tr> </table>		<b>Interdisciplinary subjects of the Perspectives in Informatics (Mandatory 2 credits)</b> Perspectives in Informatics 1 Perspectives in Informatics 2 Perspectives in Informatics 3E Perspectives in Informatics 4E Perspectives in Informatics 5E (2 credits each)	Perspectives in Platform Studies (2 credits), Computational Science, Introduction (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credit), Information Analysis and Management, Exercise (1 credit), Social Contributions through Informatics E (1 credit), Internship in the Field of Informatics E (1 credit)		
<b>Interdisciplinary subjects of the Perspectives in Informatics (Mandatory 2 credits)</b> Perspectives in Informatics 1 Perspectives in Informatics 2 Perspectives in Informatics 3E Perspectives in Informatics 4E Perspectives in Informatics 5E (2 credits each)	Perspectives in Platform Studies (2 credits), Computational Science, Introduction (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credit), Information Analysis and Management, Exercise (1 credit), Social Contributions through Informatics E (1 credit), Internship in the Field of Informatics E (1 credit)				
<b>Specific subjects provided by the school</b>					
Prior to admission	Differential and Integral Calculus Linear algebra Fundamental background of the subjects provided by the Course, etc.				

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

## Mechanical Systems Control

### Control Theory and Applications

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

[Shun-ichi Azuma , Ikumi Banno]



Control of conveyor robots

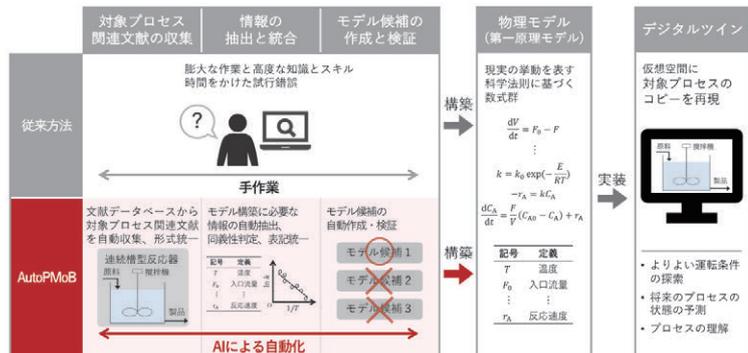


Control of a swarm robot system

## Human Systems

### Aiming to develop human-centered system design methodology

Designing systems that benefit society require modeling phenomena in actual communities that include people. This lab carries out research that can be applied in people's everyday lives and manufacturing processes leveraging machine learning, such as to build digital twins with a wide range of sensor data and simulation technologies and develop AI that automatically builds physical models. We also conduct applied research in a variety of fields to return research outcomes back to the community, such as achieving clean manufacturing and developing medical and healthcare services in collaboration with experts. Through these R&D activities, we aim to develop talent with broad horizons and high ambition.



Development of AI for automatically developing physical models from literature information

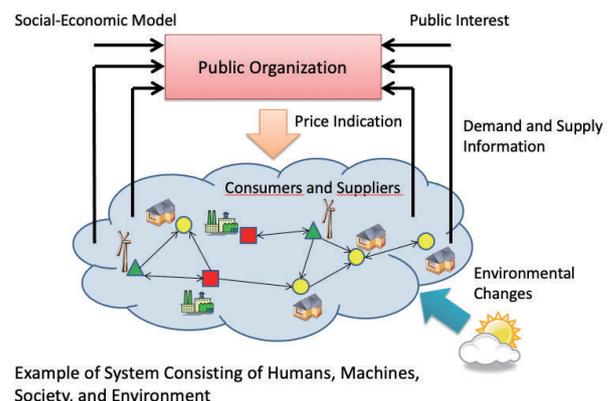
[Manabu Kano , Kana Eguchi , Shota Kato]

## Integrated Dynamical Systems

### Toward harmonious coexistence of a diversity of systems

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

[Toshiyuki Ohtsuka]



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

## Outline

## Mobility Research

### *Optimizations for design and operation*

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

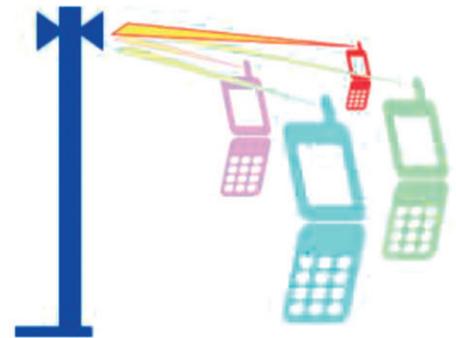
[Osamu Nishihara]

## Mathematical Information Systems

### *The mathematics of large-scale probability models*

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

[Toshiyuki Tanaka , Tomoyuki Obuchi]



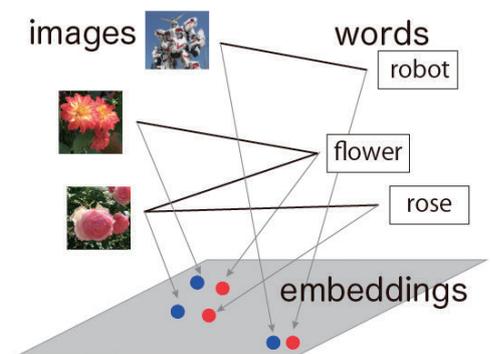
Digital communications as data science: the key to realizing high-performance digital communications lies in extracting the required information from "data" in which numerous signals interfere.

## Statistical Intelligence

### *Statistics and machine learning: Theory and applications*

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

[Hidetoshi Shimodaira , Junya Honda , Hiroaki Yamagiwa]



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

## Learning Machines

### *Toward the realization of learning machines with bodies*

The fusion field of artificial intelligence and robotics is expected to be a field that will produce the basic industrial technologies of the future. We will explore methodologies to enable machines with bodies to learn skillfully and produce desired behaviors from limited experience and data, just like humans. In order to realize learning machines

that can operate in a dynamically changing open environment, we conduct education and research on basic technologies for robot motion learning methods, mathematical models of multi-degree-of-freedom robots, and human motion intention estimation.

[Jun Morimoto, Satoshi Yagi, Satoshi Yamamori]



## Integrated Systems Biology

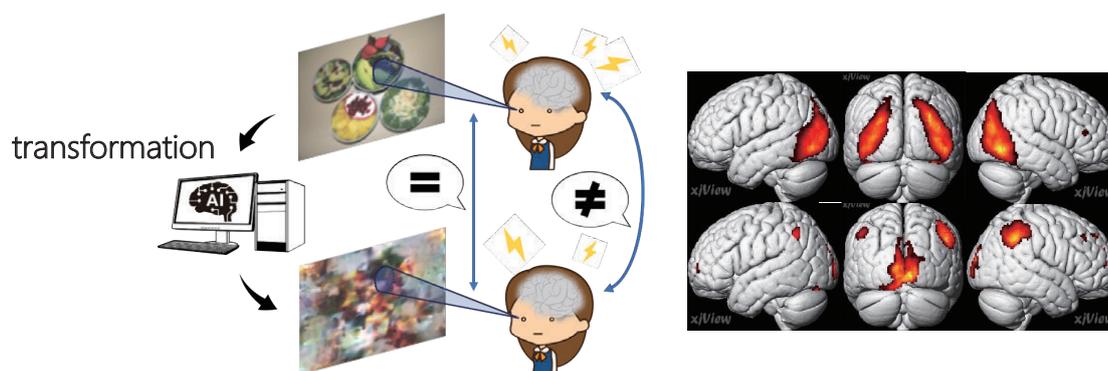
### *Constructing models of information processing in life and intelligent systems*

Intelligence (the brain) and life are complex systems that adapt to uncertain and changing environments. Aiming at elucidating the principles of information processing in those complicated systems, we are focusing on researches in the areas of computational neuroscience, systems biology, and bioinformatics, while conducting

applied research, such as the application of these principles in the building of robots that have adaptive information processing mechanisms that we have learned about through our studies of living organisms.

We conduct interdisciplinary education and research on life systems.

[Shin Ishii, Hideaki Shimazaki, Risa Katayama, PHI, Tien Cuong, GONG, Rui]



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

(Right) Brain activity when viewing "natural" and "non-natural" images differs

**Outline**

**Biocybernetics**

*Unraveling the mechanisms of homeodynamics and allostasis, their disruption in living organisms, and their medical applications*

Our primary goal is to deepen the understanding of the dynamic mechanisms underlying the expression of biological functions through interdisciplinary research in the field of biomedical engineering and informatics. We aim to establish a foundation in informatics and systems science that contributes to medical research focused on elucidating the disease mechanisms that alter biological functions due to illness. In particular, we focus on elucidating the biological control mechanisms behind homeodynamics and allostasis--the property of maintaining the optimal state of living organism. Additionally, we

are conducting research to understand the mechanisms of dynamic diseases caused by the destabilization of homeodynamics and to develop medical system foundations that enable quantitative diagnostic support for these diseases based on biological control mechanisms.

[Taishin Nomura]



Unraveling the automatic decision-making mechanisms in the brain that govern homeodynamics and allostasis

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

■ **Knowing the brain by building the brain**

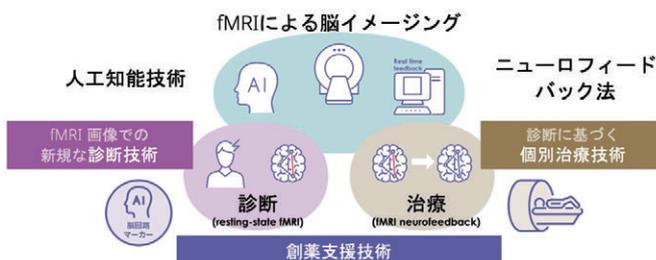
(a) Connecting the brain and artificial intelligence

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

(b) Brain-machine interface

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

**BMI技術を用いた精神疾患の診断、最適治療選択、創薬支援、治療技術の開発**



[Advanced Telecommunications Research Institute International : Mitsuo Kawato]

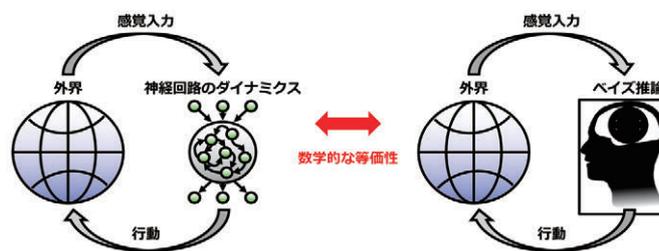
## Computational Neuroscience Adjunct Unit (In collaboration with RIKEN)

### Exploring the mechanism for emergence of intelligence from neural circuits

How do the neural cells and synaptic couplings that constitute the brain achieve the kind of superior intelligence we find in living creatures? With a view to solving this mystery, we apply mathematical approaches such as dynamic theory, Bayesian statistics, machine learning, and the free energy principle to construct a universal theory of the brain. We

focus particularly on topics such as internal model learning in the cerebral cortex and the mechanisms of memory and spatial awareness in the hippocampus. We aim to apply our findings in the development of new artificial intelligence algorithms, psychiatric disorder models and the like.

[RIKEN: Takuya Isomura, Louis Kang]



Neural circuit dynamics and plasticity potentially apply Bayesian inference

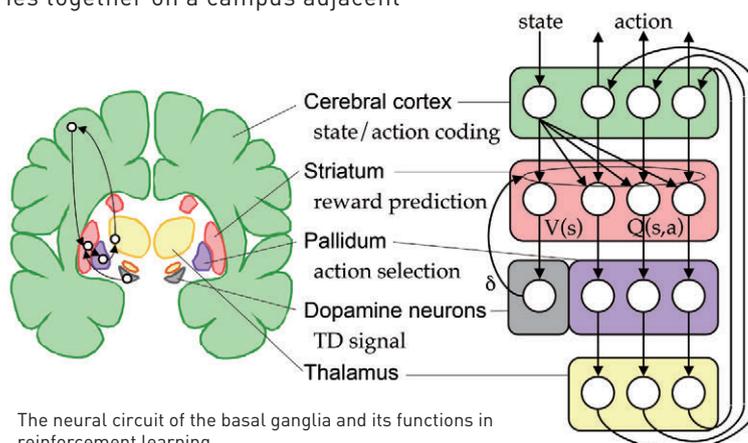
## Computational Neuroscience Adjunct Unit (In collaboration with Okinawa Institute of Science and Technology)

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

Humans and other animals can acquire new behaviors in line with various environments. What workings of the brain enable such acquisition? Answering this question requires a complementary approach to developing computational theories and algorithms on action learning in diverse environments and explicating the mechanisms of neural cells and molecular networks in the brain. Our lab brings researchers from a variety of different fields and countries together on a campus adjacent

to the ocean in Okinawa to pursue research on topics including development of new algorithms for reinforcement learning and Bayesian inference, using those algorithms in action learning by robots and applications to bioinformatics, experiments in measurement and control of activity in the cerebral cortex, basal ganglia, and serotonin neurons of rats and mice, explication of human action learning and brain activity, and evolution of group behavior objectives and learning processes in robots.

[Okinawa Institute of Science and Technology:  
Kenji Doya]



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

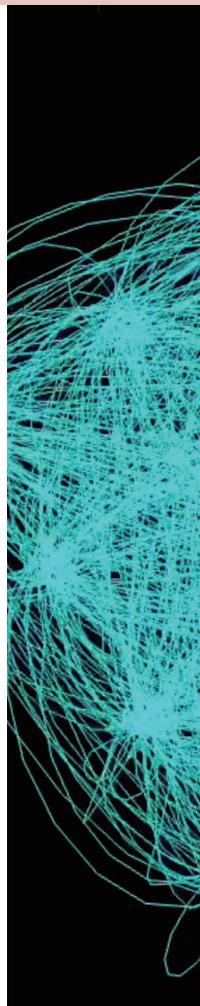
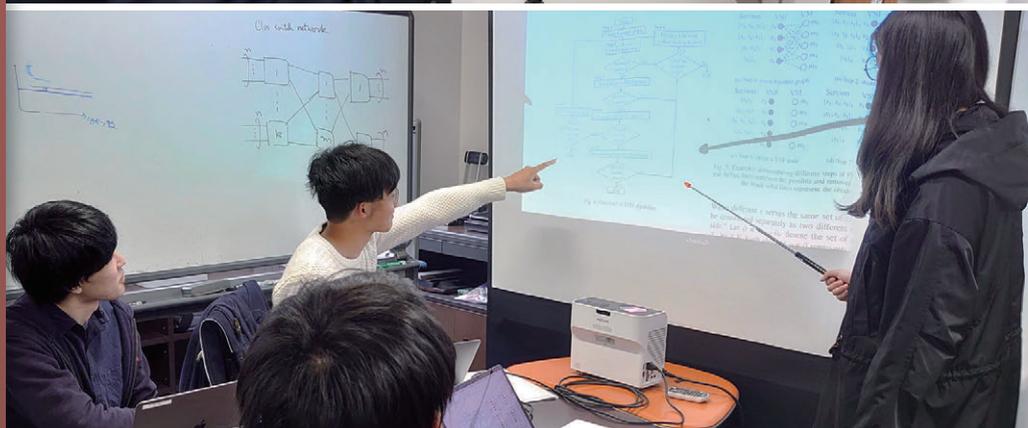
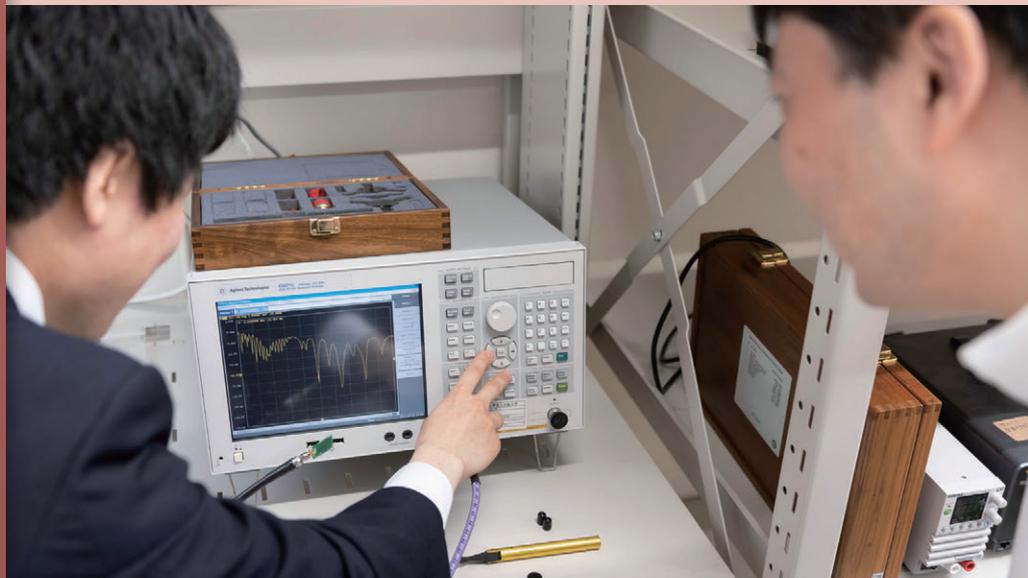
## Towards the Establishment of Fundamental Technologies in the Information Age

Advanced information processing and communications are indispensable for our society to prosper in the 21st century.

Information processing devices typified by computers are called upon to achieve high performance and be highly functional and compact.

In communications, we should be able to enjoy high-speed, reliable transmission of a vast amount of multimedia data anytime, anywhere.

The Course of Communications and Computer Engineering supports the development of future technologies in the fields of information processing devices and digital communications.



## Constructing Information and Communication Infrastructure for an Innovative Society

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

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

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

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



### *Hiroshi Harada*

*Professor, Communications and Computer Engineering Course*

He received his Ph.D. degree from the Graduate School of Engineering, Osaka University in 1995. He joined the Communications Research Laboratory, Ministry of Posts and Communications, (currently National Institute of Information and Communications Technology: NICT). After working as a researcher at Delft University of Technology, the Netherlands, a research manager and research director at NICT, and laboratory director at the Singapore Laboratory of NICT, he became a professor at Graduate School of Informatics, Kyoto University in 2014. Since 1995, he has been involved in the research, development, international standardization, and commercialization of mobile wireless communication systems and wireless communication systems for the Internet of Things.

He received the Commendation for Science and Technology from the Minister of Education, Culture, Sports, Science and Technology in 2014, the Achievement Awards from IEICE in 2006 and 2018, and the Working Group Chair Awards from IEEE Standard Association for the contributions of five international standards on wireless communication

## Outline

### Group and Teaching Staff

Group	Teaching Staff
<b>Computer Algorithms</b>	Shin-ichi Minato/Professor Jun Kawahara/Associate Professor Jesper Jansson/Program-Specific Associate Professor Yuni Iwamasa/Assistant Professor Ryota Yasudo/Assistant Professor
<b>Computer Architecture</b>	
<b>Computer Software</b>	Atsushi Igarashi/Professor Kohei Suenaga/Associate Professor Masaki Waga/Assistant Professor Mirai Ikebuchi/Assistant Professor Chiao Hsieh/Program-Specific Assistant Professor Yusuke Matsushita Program-Specific Assistant Professor
<b>Digital Communications</b>	Hiroshi Harada/Professor Yusuke Koda/Assistant Professor
<b>Integrated-Media Communications</b>	
<b>Intelligent Communication Networks</b>	Eiji Oki/Professor Takehiro Sato/Associate Professor Ryuta Shiraki/Assistant Professor
<b>Processing Architecture and Systems</b>	Takashi Sato/Professor Hiromitsu Awano/Associate Professor
<b>Low-power Integrated Circuit Design</b>	Kiichi Niitsu/Professor Kunyang Liu/Assistant Professor Ruilin Zhang/Program-Specific Assistant Professor
<b>Integrated Computing Systems</b>	Masatoshi Hashimoto/Professor Rei Ueno/Associate Professor Ryo Shirai/Assistant Professor
<b>Remote Sensing Engineering</b>	Mamoru Yamamoto/Professor Tatsuhiro Yokoyama/Associate Professor
<b>Atmospheric Observations</b>	Hiroyuki Hashiguchi/Professor Koji Nishimura/Associate Professor
<b>Supercomputing</b>	Takeshi Iwashita/Professor Kengo Suzuki/Assistant Professor
<b>Multimedia and Secure Networking</b>	Yasuo Okabe/Professor

### Curriculum of Communications and Computer Engineering Course

Doctoral Program (Informatics)	
3 <sup>rd</sup>	Doctoral Thesis
2 <sup>nd</sup>	<b>Subjects provided by the Course (total 6 credits including 4 credits from seminars)</b> Seminar on Communications and Computer Engineering, Adv. A, B, E (1 credit each) Seminar on Computer Engineering, Adv. A, B, E, Seminar on Communication Systems Engineering, Adv. A, B, E, Seminar on Integrated Systems Engineering, Adv. A, B, E, Seminar on Radio Atmospheric Science, Adv. A, B, E, Seminar on Communication and Computer System, Adv. A, B, E (2 credits each)
1 <sup>st</sup>	
	Research Guidance
Master's Program (Informatics)	
Master's Thesis	
2 <sup>nd</sup>	<b>Subjects provided by the Course (optional 12 credits or more, including recommended subjects provided by other Courses)</b>
1 <sup>st</sup>	
	<b>Advanced Subjects</b> Design in ICT, Theory of Computational Complexity E, Parallel Computer Architecture, Hardware Algorithm, System Verification E, Formal Semantics of Computer Programs, Transmission Media Engineering, Adv., Integrated System Architecture and Synthesis, System-Level Design Methodology for SoCs E, Atmospheric Measurement Techniques E, Remote Sensing Engineering, Computer Network, Advanced, Supercomputing, Advanced (2 credits each)
	<b>Basic Subjects</b> Theory of Discrete Algorithms, Introduction to Algorithms and Informatics, Digital Communications Engineering, Information Networks, Integrated Circuits Engineering, Adv. (2 credits each)
	<b>Recommended subjects provided by other Course (4 credits, Mandatory)</b> Language Information Processing, Adv. E (IST), Biosphere Informatics E (SI), Cryptography and Information Society (SI) (2 credits each)
	<b>Seminars and exercises for Master's thesis (Mandatory 10 credits)</b> Advanced Study in Communications and Computer Engineering 2E (Assigned to M2, 5 credits) Advanced Study in Communications and Computer Engineering 1E (Assigned to M1, 5 credits)
	<b>General Subjects provided by the school</b>
	<b>Interdisciplinary subjects of the Perspectives in Informatics (Mandatory 2 credits or more, up to 4 credits)</b> Perspectives in Informatics 1 Perspectives in Informatics 2 Perspectives in Informatics 3E Perspectives in Informatics 4E Perspectives in Informatics 5E (2 credits each)
	Perspectives in Platform Studies (2 credits), Computational Science, Introduction (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credit), Information Analysis and Management, Exercise (1 credit), Social Contributions through Informatics E (1 credit), Internship in the Field of Informatics E (1 credit)
	Specific Subjects provided by the school
<b>Prior to admission</b>	Communications and Radio Engineering    Logic and Integrated Circuits Engineering    Computer Engineering    Theoretical Computer Science    Understanding at the undergraduate level in at least two of these areas

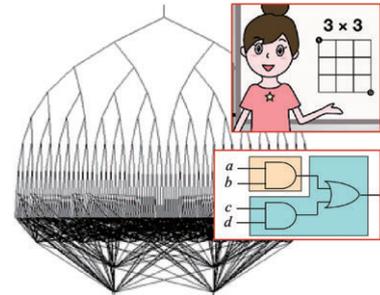
Note: Subjects marked with the letter "E" will be provided in English.

## Computer Algorithms

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

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

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



## Computer Software

*Theory and practice for efficient and dependable software*

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

[Atsushi Igarashi , Kohei Suenaga , Masaki Waga , Mirai Ikebuchi , Chiao Hsieh , Yusuke Matsushita ]



**Outline**

**Digital Communications**

*Toward ubiquitous wireless information networks*

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



[Hiroshi Harada , Yusuke Koda]

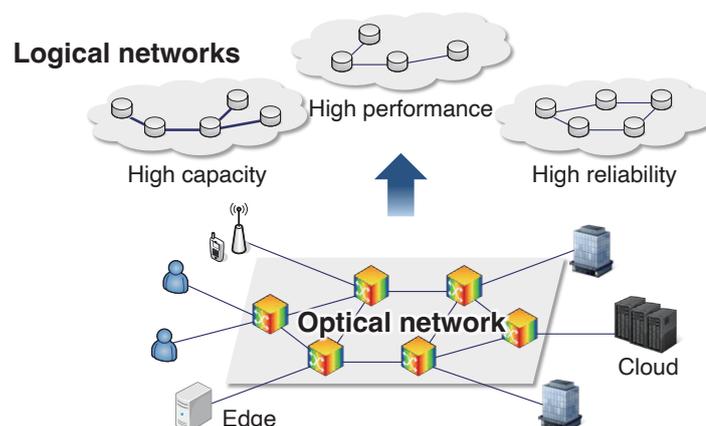
**Intelligent Communication Networks**

*Exploring information and communication network paradigms*

The advancement of the Internet of Things (IoT) and big data technologies has enabled the networking of all types of devices around us and the provision of a diverse variety of services through data processing on cloud and edge platforms. Establishing these types of systems as social infrastructure will require technologies for the sophisticated design and control of networks

for the transmission and reception of large volumes of traffic and computer resources to collect and analyze data. Our laboratory conducts research on high-speed, reliable, and flexible information communication networks using a broad range of theoretical and practical approaches.

[Eiji Oki , Takehiro Sato , Ryuta Shiraki]

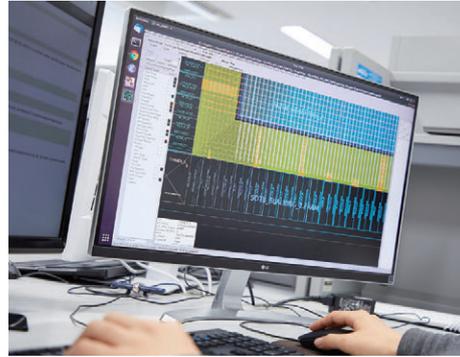


## Processing Architecture and Systems

### *Architecture design methodology for system LSIs*

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

[Takashi Sato , Hiromitsu Awano]

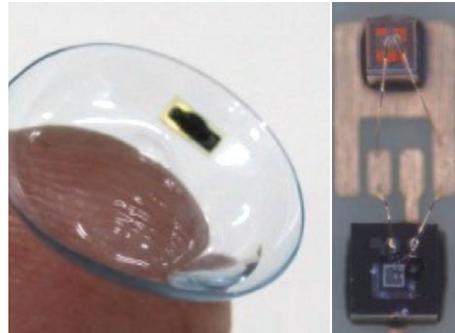


## Low-power Integrated Circuit Design

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

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

[Kiichi Niitu , Kunyang Liu , Ruilin Zhang]



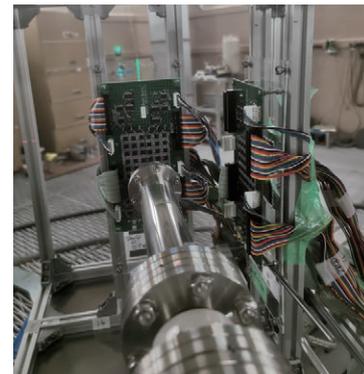
Power-independent continuous blood glucose monitor contact equipped with 65 nm CMOS IC and glucose power element

## Integrated Computing Systems

### *Design and application of integrated systems*

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

[Masanori Hashimoto , Rei Ueno , Ryo Shirai]



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

**Outline**

**Remote Sensing Engineering**

*Exploration of the Earth's atmosphere through radars*

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

deep cumulus convection is more prevalent there than anywhere else.

[Mamoru Yamamoto , Tatsuhiro Yokoyama]



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

**Atmospheric Observations**

*Towards developing new observation techniques to obtain atmospheric environmental information*

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

[Hiroyuki Hashiguchi , Koji Nishimura]



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

## Supercomputing

*Aiming to be at the forefront of computing performance*

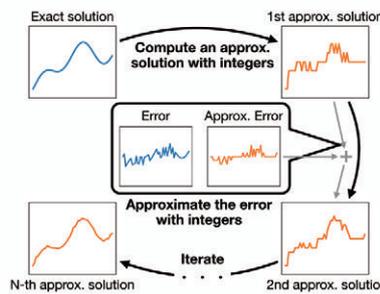
We conduct research on high performance computing (HPC). HPC is the study of the methodology and implementation methods to run a wide range of applications on computers at the highest performance possible. "High-performance" here refers not only computational speed, but also to a wide variety of indicators including power consumption. This group mainly covers matrix computation used in many forms of

analysis and machine learning, and conducts research and development on themes such as parallel computing algorithms, GPU algorithms, and implementation methods. Programs we develop are publicly released in libraries with the aim of widely benefiting society. We are also actively working on joint research projects with researchers in applied fields to contribute to the development of practical high-performance programs.

[Takeshi Iwashita, Kengo Suzuki]



Supercomputer at the Academic Center for Computing and Media Studies



Framework for numerical analysis based on integer arithmetic

## Multimedia and Secure Networking

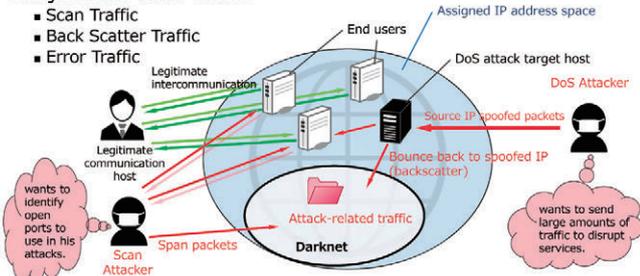
*Towards a ubiquitous networking world*

Society 5.0 is a vision of a future society in which computers and network functions are embedded into everything, characterized by a high degree of integration between cyberspace and physical space through "anytime, anywhere" network connections. As fundamental technologies to support this kind of society, we are pursuing research on next-generation Internet technologies such as programmable networks and

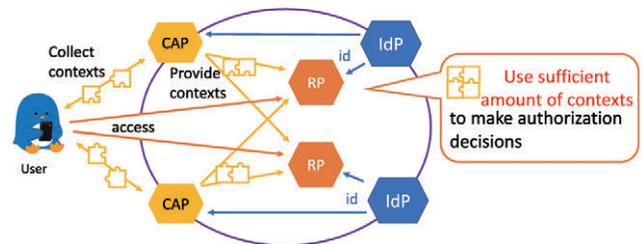
protocols that use such networks, operational technologies such as automated configuration, platform technologies that support assorted services such as identity federation, and security. As the network research division of the Academic Center for Computing and Media Studies, we also perform numerous empirical studies using operational networks, both on and off campus.

[Yasuo Okabe]

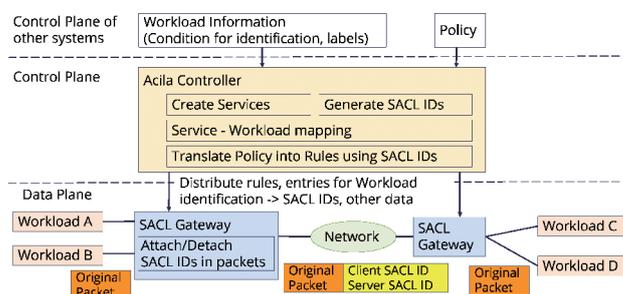
### Major Observable Traffic



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



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



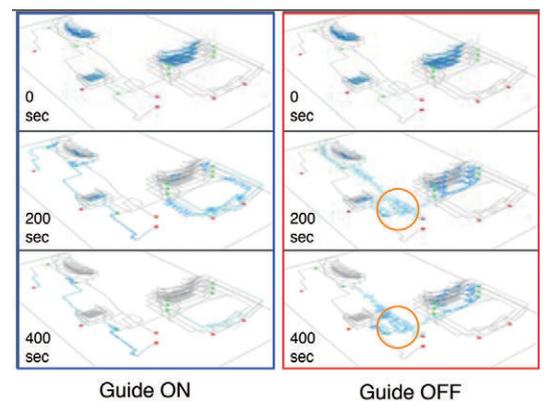
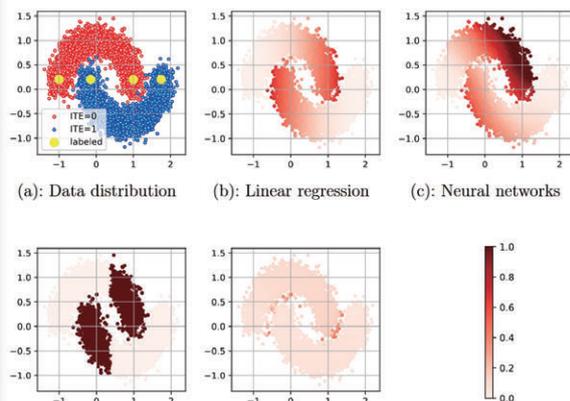
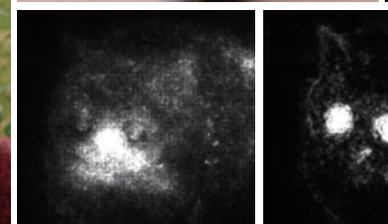
Network access control using workload identities for cloud operations

# Data Science and Beyond

Data science has become very important in recent years as a methodology for inductively constructing models and hypotheses from data.

This trend has also spilled over into other academic disciplines, such as medicine, education, disaster prevention, agriculture, economics, and linguistics, leading to a surge in demand for data scientists in industries spanning agriculture and manufacturing, distribution and retailing, and finance and entertainment. The new Data Science Course, established in April 2023 as a center for education and research in mathematics, data science, and machine learning, also serves to foster top-class data science experts.

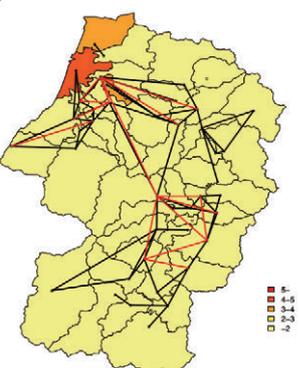
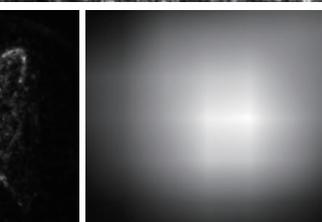
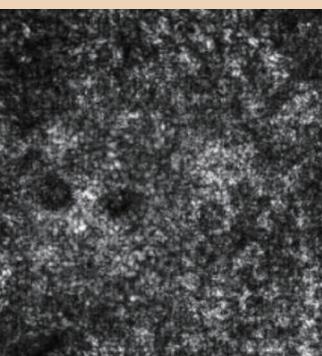
By actively welcoming students and researchers from adjacent disciplines, we also contribute to the creation of new interdisciplinary academic fields.



## Data Science is Drawing a Lot of Attention

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

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



### *Hisashi Kashima*

*Data Science Course*

Hisashi Kashima is a professor at the Graduate School of Informatics, Kyoto University since 2014.

He received his B.S. in 1997, M.S. in 1999, and Ph.D. in 2007 from Kyoto University.

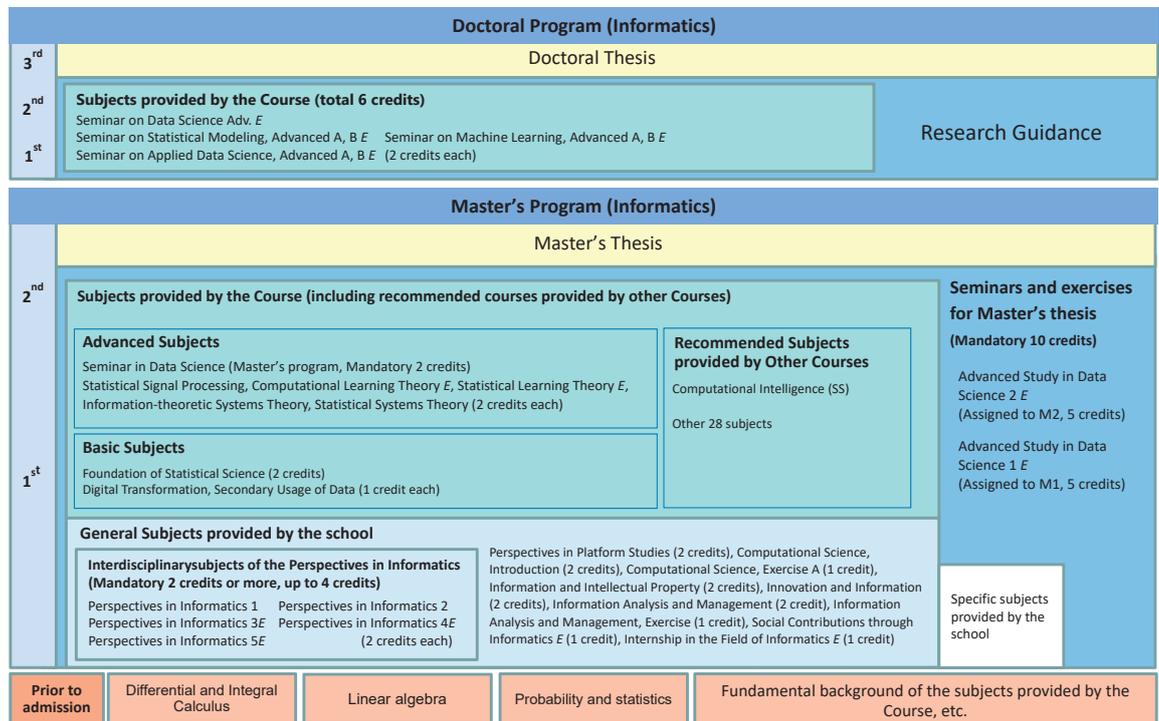
He joined IBM Research in 1999. From 2009 to 2014, he was an Associate Professor at the University of Tokyo.

**Outline**

**Group and Teaching Staff**

Group	Teaching Staff
<b>Statistical Mathematics</b>	Hidetoshi Shimodaira/Professor Junya Honda/Associate Professor Hiroaki Yamagiwa/Assistant Professor
<b>Statistical Inference</b>	Hisayuki Hara/Professor (Secondary appointment : Institute of Liberal Arts and Sciences)
<b>Information-Theoretic Learning</b>	Toshiyuki Tanaka/Professor Tomoyuki Obuchi/Associate Professor
<b>Signal and Information Processing</b>	Kazunori Hayashi/Professor (Secondary appointment : Institute of Liberal Arts and Sciences)
<b>Applied Machine Learning (Computational Intelligence)</b>	Akihiro Yamamoto/Professor Brendan John Flanagan /Program-Specific Associate Professor(Institute of Liberal Arts and Sciences) Nozomi Akashi/Assistant Professor
<b>Applied Machine Learning (Collective Intelligence)</b>	Hisashi Kashima/Professor Koh Takeuchi/Senior Lecturer Kyohei Atarashi/Assistant Professor
<b>Medical and Healthcare Data Science</b>	Hiroshi Tamura/Professor (Secondary appointment : Institute of Liberal Arts and Sciences)
<b>Computational Intelligence Systems (Adjunct unit)</b>	Tomoharu Iwata/Kyoto University Visiting Professor (NTT Communication Science Laboratories)

**Curriculum of Data Science Course**



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

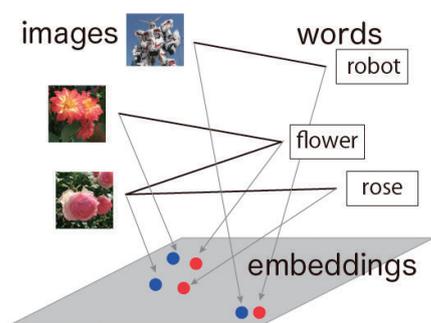
## Statistical Mathematics

### Theory and Application of Statistics and Machine Learning

Statistics plays a vital role as the theoretical foundation of the highly influential trends of big data, data mining, and AI. A key feature of statistics is that it provides a methodology for making inductive inferences from data, in a way that accounts for randomness. On this foundation, machine learning has developed very rapidly in

recent years, from extracting information from large volumes of data to making decisions utilizing only small amounts of data. Our aim at this turning point is to develop new methodologies driven by mathematics and programming to use with real-world data.

[Hidetoshi Shimodaira, Junya Honda, Hiroaki Yamagiwa]



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

## Statistical Inference

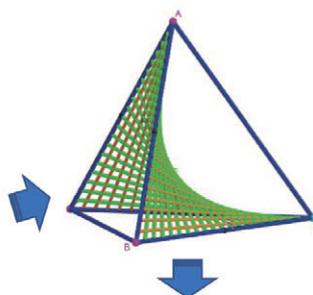
### Mathematics of Statistical Inference in the Age of Big Data and Its Applications

With the rise of big data, machine learning, and AI, statistical inference theory and algorithms for statistical inference in high-dimensional complex systems are increasingly important. Although massive quantities of data are now readily accessible, the complexity of the phenomena we want to understand clearly remains daunting. It is therefore necessary to develop robust inference methods that allow us to make reliable inferences

using even small sample sizes. Our research and education are focused on the development of high-dimensional inference methods and their application to fields as diverse as archaeology, anthropology, and cognitive science, by making use not only of classical inference methods but also various mathematical techniques such as combinatorics, algebraic geometry, and optimization methods.

[Hisayuki Hara]

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



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

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

Outline

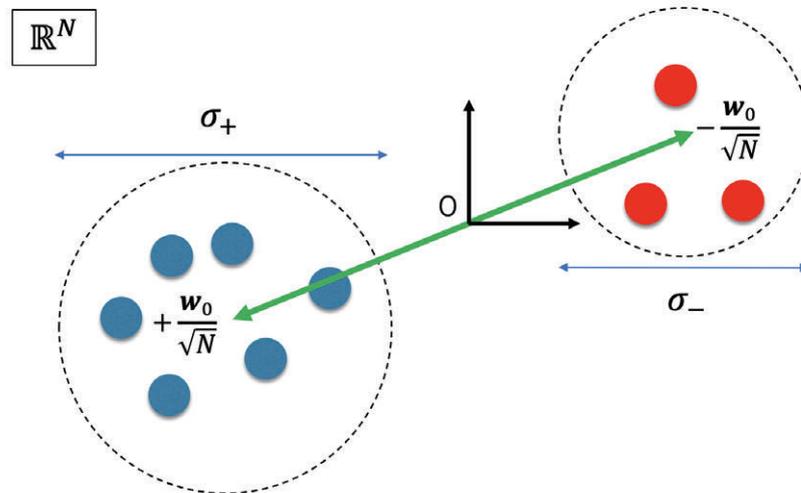
## Information-Theoretic Learning

### *Information Mathematics for Machine Learning*

Over recent years, deep learning has advanced enormously, with a rich variety of ideas and models generated and proposed. In addition to deep learning, other methods of machine learning have also been developed for dealing with various challenges confronted in data science. In some cases, the reasons why such methods are effective or the properties of such methods are not even

understood. Our aim is to shed light on the mechanisms of these methods via utilizing knowledge from information theory and the statistical mechanics of disordered systems.

[Toshiyuki Tanaka, Tomoyuki Obuchi]

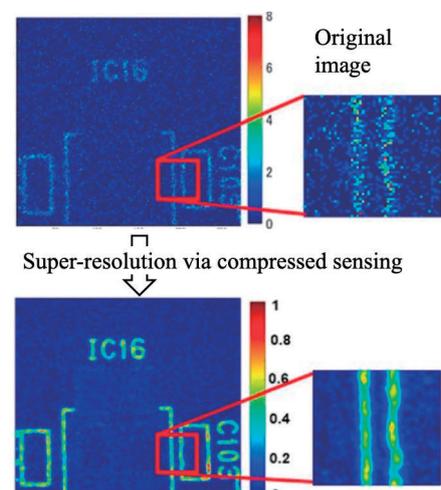


## Signal and Information Processing

### *Statistical signal processing and model-based machine learning*

In the field of signal and information processing, we research model-based machine learning, which combines the model-based approach of statistical signal processing and the data-driven approach of machine learning, as a methodology for extracting useful information from observed raw signals and data. We tackle a wide range of engineering problems including measurement, image processing, and biosignal processing, with a focus on communication systems such as wireless communications, optical fiber communications, and IoT.

[Kazunori Hayashi]



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

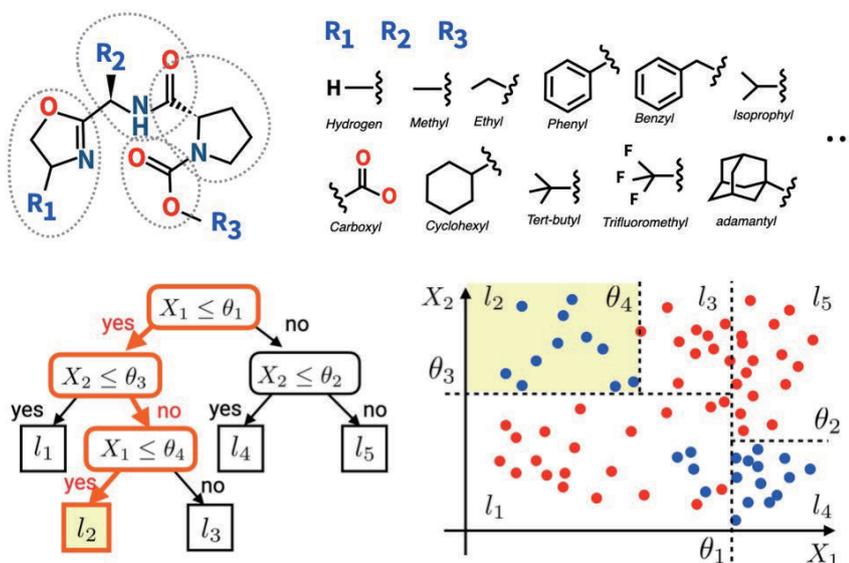
## Applied Machine Learning (Computational Intelligence)

### Machine Learning and Data Science for Solving Real-world Problems

In our work on applied machine learning (computational intelligence), we conduct practical research on machine learning and data science with a view to developing solutions to real-world problems and challenges in the fields of natural sciences and education. In life sciences and chemistry, discrete combinatorial structures, such as genome sequences, molecular structures, and intermolecular interactions, need to be reflected in machine learning. We are developing technology to address these need. In education, we are working on the development of an educational information platform and methodology to improve the effectiveness and efficiency of our own learning. Our goal is to pave the way for a new foundation for computational intelligence, by

making concrete implementation through scientific discovery and understanding; through integration with general discrete structure processing using symbolic logic, knowledge representation, and algorithm design; and by comparison between human and machine learning.

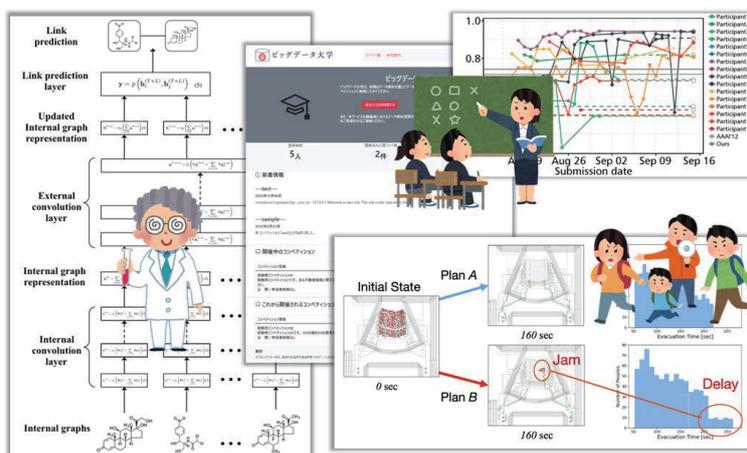
[Akihiro Yamamoto, Brendan John Flanagan , Nozomi Akashi]



## Applied Machine Learning (Collective Intelligence)

### Pioneering Innovative Applications of Data Analytics

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



Leveraging advanced analytics to address challenges across various domains.

[Hisashi Kashima , Koh Takeuchi , Kyohei Atarashi]

## Outline

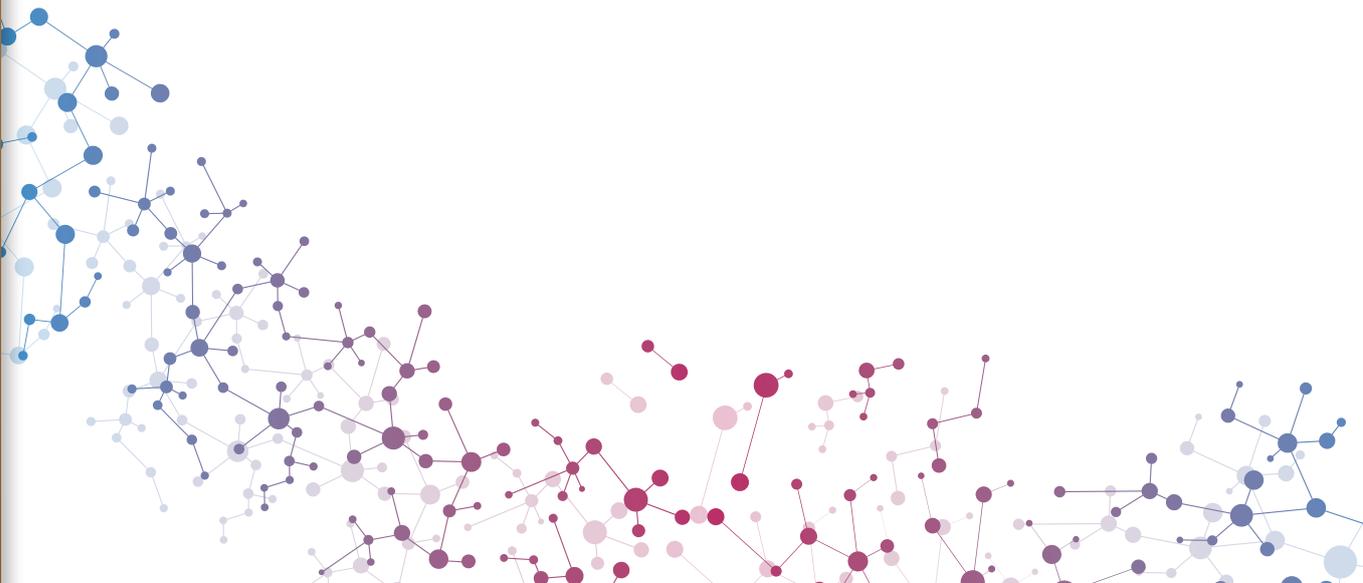
## Medical and Healthcare Data Science

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

## Research Themes

- **Epidemiological research utilizing clinical data including imaging and genetic data**  
Clinical research consisting mainly of observational studies, in combination with multimodal imaging and genetic data, elucidating pathophysiology or predicting prognosis.
- **Epidemiological research utilizing claims data, including the National Database of Health Insurance Claims and Specific Health Checkups of Japan (NDB)**  
Epidemiological studies based on the secondary use of claims data, which plays a central role in the Data Health Plan featured in the Japan Revitalization Strategy
- **Research on implementation and improvement of hospital information systems for improving hospital management**  
Research aimed at improving hospital management by organizing and verifying implementation of issues in the renovation, improvement, and secondary use of hospital information systems involving new technologies such as IoT and AI
- **Research on the development of a gaze analyzing visual function evaluation device**  
Study that aims to implement a wide range of visual function evaluation systems, which also include cognitive functions, using a “gaze analyzing visual function evaluation device” that features eye tracking and AI

[Hiroshi Tamura]



## Computational Intelligence Systems (Adjunct Unit)

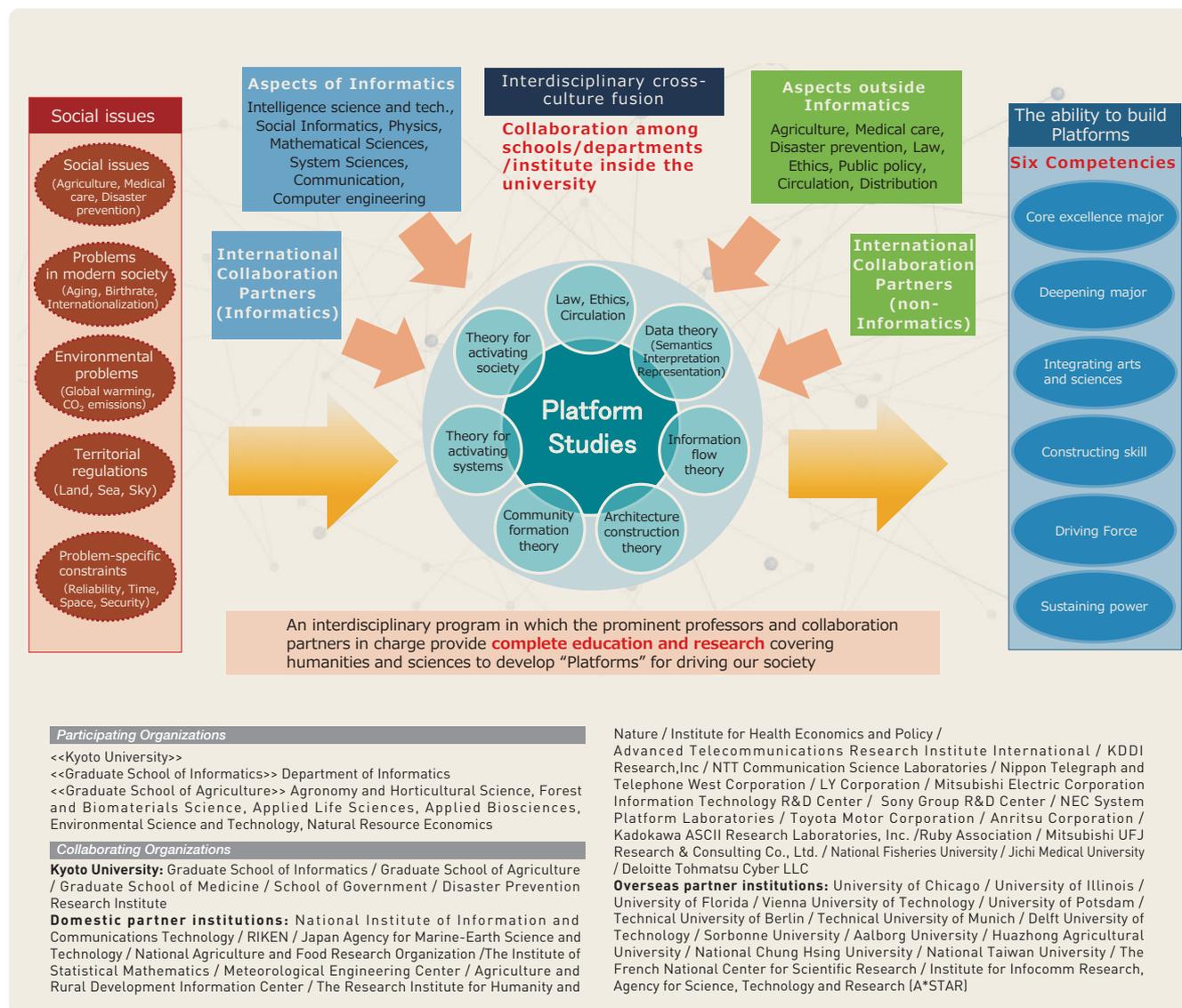
### *Toward Knowledge Creation from Diverse Data*

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

[NTT Communication Science Laboratories: Tomoharu Iwata]

## Kyoto University School of Platforms (KUSP)

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



### ● Platform Studies for Activating Society

Currently, efforts are fast underway to develop and utilize "platforms" that use telecommunications technology to collect information that is non-uniformly spread throughout our society. This information is digitally stored in the form of big data, which is then categorized, analyzed, and shared so that any outcome of the process may be fed back to society. The present platforms need a considerable amount of electric power and computational capability to collect and process big data. However, we can reduce the power consumption and costs if we consider the processes involved in decentralization, safety, and speed in the data generation and collection process. This requires exceptional informatics knowledge, which has as its focal point information and communication

technologies. Meanwhile, deep learning and machine learning have become standard techniques and are often used in black boxes. Yet, it is possible to improve the output while reducing costs by correctly understanding and interpreting the data's meaning in each specific field and optimizing it. To achieve this, informatics must be combined with knowledge of different disciplines such as agriculture, medical science, disaster management, and other scientific studies.

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

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

### ● The Six Competencies Required of Platform Builders

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

To ensure that students acquire "outstanding core expertise" in the areas of their primary major, the program provides students with

lectures and seminars on such fields as informatics, agriculture, medical science, and disaster management, which are expected to help them deepen understanding of sub-fields while paying due regard to the curriculum of individual students' majors. Also provided are lectures and seminars on laws, ethics, data distribution, and other humanities studies needed to build platforms, which are designed to cultivate the ability to integrate humanities and sciences. Based on these inputs and research outcomes, students are expected to develop the skills to build platforms on their own initiatives, to promote/manage projects and implement and expand their results globally, and to standardize and socially implement the results so that they can develop the results in a sustainable manner. To assist them in doing so, the program offers guidance from instructors in multiple fields, research grants, research internships, research outcome matching events, international symposia, and other opportunities. Students will also be given access to state-of-the-art communication environments and various types of big data. These opportunities will be provided through industry-university-government cooperation among 40 institutions both within and outside of Kyoto University, including the Graduate School of Informatics, Graduate School of Agriculture, Graduate School of Medicine, School of Government, and Disaster Prevention Research Institute.

- Website : <https://www.platforms.ceppings.kyoto-u.ac.jp/>
- E-mail : [platforms\\_contact@mail2.adm.kyoto-u.ac.jp](mailto:platforms_contact@mail2.adm.kyoto-u.ac.jp)

## Kyoto University Collaborative Graduate Program in Design

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

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

### Participant Organizations

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

### Partner Organizations

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

- Website : <https://www.design.kyoto-u.ac.jp>
- E-mail : [contact@design.kyoto-u.ac.jp](mailto:contact@design.kyoto-u.ac.jp)

## International Program at Graduate School of Informatics

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

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

These programs are open both international and domestic students.

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

The purpose of the G30 Program was to cultivate top-notch individuals who would play an active role in the global arena by providing development opportunities

through friendly competition with international students. Participating universities were called upon to provide quality education according to their respective functions and to create an environment that makes it easier for international students to study in Japan. To this end, the G30 program assisted Japan's leading universities generating a hub of internationalization, including development a system in which degree programs can be offered entirely in English, improving the environment to accept international students, and promoting of strategic international cooperation.

- International Programs website : [https://www.i.kyoto-u.ac.jp/education/intl\\_program/](https://www.i.kyoto-u.ac.jp/education/intl_program/)
- Contact : [jyoho-kyomu@mail2.adm.kyoto-u.ac.jp](mailto:jyoho-kyomu@mail2.adm.kyoto-u.ac.jp)  
(Student Affairs Division)



## Curriculum Policy

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

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

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

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

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

- **General Subjects Provided by the School (Compulsory Elective)**

The subjects "Perspectives in Informatics" are offered to help students acquire insights about the extent of informatics. Students are required to take at least one of these classes according to the requirements specified by their course.

- **Seminars and Exercises for Master's Thesis (Mandatory)**

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

- **Basic Subjects and Subjects Provided by the Course (Optional)**

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

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

- **Auditing Subjects offered for undergraduate courses**

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

### Requirements for Completion of the Master's Program —

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

- **Seminars and exercises for Master's thesis (Mandatory) and Master's thesis (Mandatory)**

- **General subjects provided by the School (Compulsory elective)**

- **Basic Subjects and Subjects provided by the Course (Including Subjects Provided by Other Courses, Optional)**

### Requirements for Completion of the Doctoral Program —

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

- **Doctoral Thesis (Mandatory)**

## Academic Programs

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

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

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

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

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

Please see the application guideline for details.

### ■ Admission Quota

	Master’s Program	Doctoral Program
Department of Informatics	240	65

### ■ The Number of Students to be Admitted by Course

	Master’s Program	Doctoral Program
Intelligence Science and Technology Course	42	15
Social Informatics Course	50	15
Advanced Mathematical Sciences Course	20	6
Applied Mathematics and Physics Course	28	6
Systems Science Course	31	8
Communications and Computer Engineering Course	51	11
Data Science Course	18	4

## Financial support for doctoral program students

If you wish to be a proficient researcher who leads development in informatics, you should enroll in a doctoral program. Kyoto University provides financial support for graduate students in its doctoral programs.

The university currently conducts two programs to lower the financial obstacles in obtaining a doctoral degree: The Kyoto University Division of Graduate Studies (DoGS) SPRING Program and DoGS Next AI Program.

Recipients can participate in the program of their choice to enhance their research prowess and build a career path in

diverse academic and industrial fields after completing the program.

Recipients have delivered research presentations at the Kyoto University ICT Innovation, joined long-term abroad programs, participated in research internships, and served as teaching assistants in data science.

● <https://www.kugd.k.kyoto-u.ac.jp/support>

● [https://www.i.kyoto-u.ac.jp/education/DoGS\\_SPRING/](https://www.i.kyoto-u.ac.jp/education/DoGS_SPRING/)

#### ● DoGS SPRING Program

- Number of anticipated recipients (all Kyoto University students): about 800
- Stipends: JPY2.16 million per year (in monthly installments of JPY180,000)
- Research fund: JPY400,000 per year
- Half tuition exemption

#### ● DoGS Next AI Program

- Number of anticipated recipients: 40
- Stipends: JPY3.00 million per year (in monthly installments of JPY250,000)
- Research fund: JPY900,000 per year
- Full tuition exemption

● Selection: Applicants submit a statement of past research and research plan, as well as a letter of recommendation by their supervisors, based on which their past academic and research achievements and research perspectives after enrollment will be screened.

## Career path after graduation

### 【Master's students】

Financial Services Agency

Japan Patent Office

Shiga Prefecture

city office of Kitakyushu

Aioi Nissay Dowa Insurance Co., Ltd

AISIN CORPORATION

International Business Machines Corporation

AIFUL CORPORATION

ACCESS CO., LTD

Accenture Japan Ltd

AKKODiS Consulting Ltd.

ASAHI KASEI CORPORATION

Amazon Web Services Japan

Amazon Japan G.K

Western Digital GK

ExaWizards Inc

SNK CORPORATION

estie, inc.

SBI SECURITIES Co.,Ltd.

NTT R&D

NTT DATA Group Corporation

NTT DATA TOKAI CORPORATION

NTT FINANCE CORPORATION

NTT DOCOMO, INC.

M3, Inc.

Honor Device

OMRON Corporation

Katariba

CAPCOM CO., LTD

KEYENCE CORPORATION

Canon IT Solutions Inc.

QUNIE CORPORATION

KDDI CORPORATION

KPMG Consulting Co., Ltd

GAME FREAK Inc

Goldman Sachs Japan Co., Ltd

Konami Digital Entertainment Co., Ltd

COLOPL,Inc.

Geniee, Inc.

Shiftmation,Inc.

Shimadzu Corporation

Sharp Corporation

Japan Advanced Semiconductor Manufacturing

Simplex Holdings, Inc

SEGA CORPORATION

ZS Associates International, Inc.

Sony Corporation

Sony Honda Mobility Inc

Sony Music Entertainment (Japan) Inc.

Sony Group Corporation

Sony Semiconductor Solutions Corporation

SoftBank Corp.

TSMC Design Technology Japan, Inc.

Disco Corporation

Deloitte Tohmatsu Financial Advisory LLC

DENSO

DENTSU INC

Tokyo Electron Ltd.

Deloitte Touche Tohmatsu LLC

TOYOTA MOTOR CORPORATION

Trip.com Group Ltd.

National Software Co.,Ltd.

West Japan Railway Company

Nissan Motor Co., Ltd.

NS Solutions Corporation

IBM Japan Systems Engineering Co., Ltd.

Nippon Life Insurance Company

The Japan Research Institute, Limited

NEC Corporation

NIPPON TELEGRAPH AND TELEPHONE CORPORATION

JAPAN PROCESS DEVELOPMENT CO., LTD.

Nintendo Co., Ltd.

Nomura Securities Co., Ltd.

Nomura Research Institute, Ltd.

PERSOL AVC TECHNOLOGY CO., LTD.

ByteDance, Ltd.

Panasonic Information Systems Co., Ltd

Panasonic Automotive Systems Co., Ltd.

Panasonic Connect Co., Ltd.

Panasonic Holdings Corporation

East Japan Railway Company

Hitachi Industrial Equipment Systems Co., Ltd.

Hitachi, Ltd.

Hitachi Solutions Create, Ltd.

Hitachi Solutions Technology, Ltd.

Hitachi Channel Solutions, Corp.

Bitbank, Inc.

BIPROGY Inc.

Human Interactive Technology inc.

Huawei Technologies Co., Ltd.

Fixstars Corporation

Fujitsu Limited

Future Corporation

freee K.K.

Preferred Networks, Inc.

FLECT Co., LTD

Benesse Corporation

Benesse Holdings, Inc.

Micron Memory Japan, K.K.

Manulife Life Insurance Company

Money Forward, Inc

Marubeni Corporation

Mizuho Bank, Ltd.

Mitsubishi Heavy Industries, Ltd.

Mitsubishi Research Institute, Inc.

Mitsubishi Electric Corporation

Miraxia Edge Technology Corporation

Mercari, Inc.

MonotaRO Co.,Ltd

RIZAP GROUP, Inc.

LY Corporation

Rakuten Group, Inc.

Li Auto Inc.

Recruit Co., Ltd.

LINX Corporation

Starting a business

Chengdu People's Government Office

### 【Doctoral students】

Kyoto University

Fukushima University

National Institute of Technology (KOSEN), Maizuru College

China University of Mining and Technology

Japan Aerospace eXploration Agency

National Institute of Informatics

Institute of Physical and Chemical Research

Nomura Research Institute, Ltd.

Interprism Inc.

KPMG Consulting Co., Ltd.

Sony Group Corporation

DIGITAL PROCESS LTD.

Institute of Science Tokyo Hospital

JAPAN TOBACCO INC.

Huawei Technologies Co., Ltd.

## List of Departments, Divisions and Groups

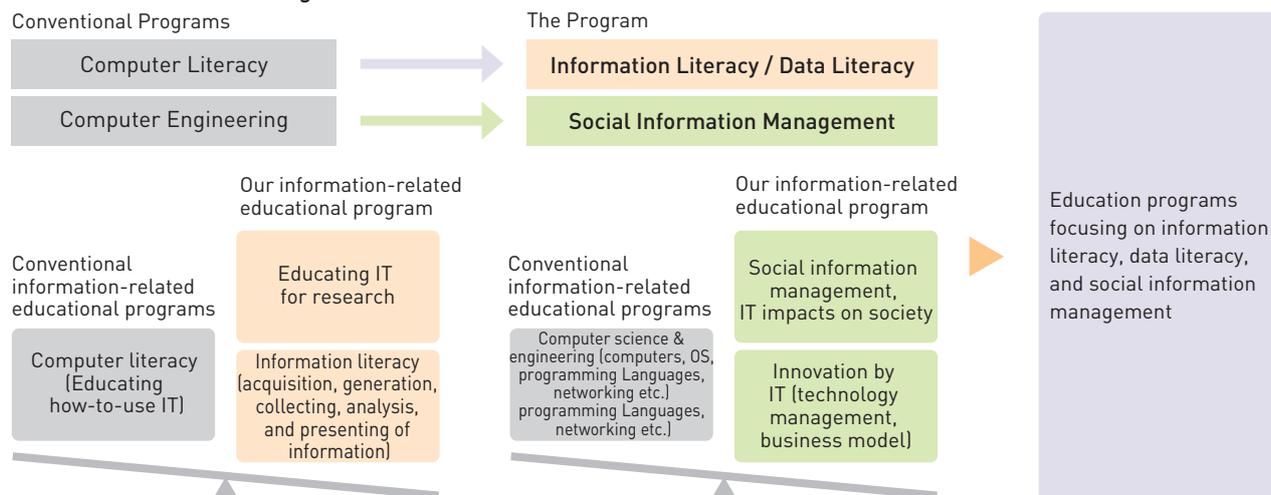
	Division	Group			
Department of Informatics	Brain and Cognitive Sciences	Neuroinformatics	Psychoinformatics	Cognitive Informatics	
	Cognitive System	Computational Intelligence	Collective Intelligence	Symbol Emergence Systems	
	Intelligence Media	Language Media Processing	Speech and Audio Processing	Computer Vision	
	Application of Multimedia (collaborative division)	Human Sensing	Text Media		
	Bio-system Informatics (collaborative division)	Biological Information Networks			
	Social Information Model	Inclusive Design	Human-Robot Interaction	Social Media Unit	
	Social Information Network	Consensus Informatics			
	Biosphere Informatics	Bioresource Informatics	Environmental Informatics		
	Regional and Disaster Management Information Systems (collaborative division)	Integrated Disaster Management Systems	Disaster Reduction Information Systems	Regional and Disaster Management Information	
	Medical Informatics (collaborative division)	Medical Informatics			
	Social Informatics Analytics Infrastructure	Learning and Educational Technologies	Data Engineering and Platform Research		
	Applied Analysis	Analysis of Inverse Problems	Analysis of Nonlinear Problems		
	Nonlinear Physics	Nonlinear Dynamics and Computational Statistical Physics	Non-equilibrium Physics and Theoretical Neuroscience		
	Applied Mathematical Sciences	Computational Mechanics	Industrial Mathematics		
	Applied Mathematics	Applied Mathematical Analysis	Discrete Mathematics		
	Applied Mathematical Systems	System Optimization	Control Systems Theory		
	Mathematical Physics	Physical Statistics	Dynamical Systems		
	Human Machine Symbiosis	Mechanical Systems Control	Human Systems	Integrated Dynamical Systems	Mobility Research
	Systems Synthesis	Mathematical Information Systems	Statistical Intelligence		
	Systems Informatics	Learning Machines	Integrated Systems Biology	Biocybernetics	
	Computer Engineering	Computer Algorithms	Computer Architecture	Computer Software	
	Communications Systems Engineering	Digital Communications	Integrated-Media Communications	Intelligent Communication Networks	
	Integrated Systems Engineering	Processing Architecture and Systems	Low-power Integrated Circuit Design	Integrated Computing Systems	
	Radio Atmospheric Sciences (Affiliated)	Remote Sensing Engineering	Atmospheric Observations		
	Information and Communication Infrastructure (collaborative division)	Multimedia and Secure Networking	Supercomputing		
	Innovative Research and Education in Data Science	Statistical Inference	Signal and Information Processing	Data Science	

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

The Advanced Information-Related Education & Digital Education Infrastructure Unit was established in Kyoto University C-PiER to implement the budget request project: Fostering Global Human Resources by Innovating Undergraduate/Graduate-level Information-related Education & Digitized Education of Graduate school of informatics, Kyoto

University. It is our hope that students who will shape the future of our society will acquire essential skills to utilize information regardless of their areas of expertise so that they can enhance their information and communication skills as well as their global mindset.

### Innovative Educational Programs



### Digitized Education Environment

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

### Faculties

#### Akihiro Yamamoto

Unit Leader /  
Professor  
Graduate School of  
Informatics

#### Nobuo Yamashita

Professor  
Graduate School of  
Informatics

#### Keishi Tajima

Professor  
Institute for Liberal Arts  
and Sciences

#### Yoshikazu Maegawa

Visiting Professor  
Graduate School of  
Management

#### Hiroyuki Sato

Part-time Lecturer  
Graduate School of  
Informatics

#### Satoshi Shimada

Part-time Lecturer  
Graduate School of  
Management

#### Huang Yin jou

Program-Specific  
Assistant Professor  
Graduate School of  
Informatics

#### Kanae Kochigami

Program-Specific  
Assistant Professor  
Graduate School of  
Informatics

### Courses

[Liberal Arts Courses]	<ul style="list-style-type: none"> <li>• Basic Informatics [General]</li> <li>• Informatics Fundamentals &amp; Practice</li> <li>• Information and Enterprise</li> </ul>	<ul style="list-style-type: none"> <li>• Introduction to Information &amp; Intellectual Property</li> <li>• Innovation and Information</li> <li>• Information and Society</li> </ul>
[Graduate Courses] Interdisciplinary Graduate Courses	<ul style="list-style-type: none"> <li>• Information Analysis and Management</li> <li>• Computational Science, Introduction</li> <li>• Exercise on Computational Science B</li> <li>• Service Modeling &amp; Applying Strategy</li> <li>• Innovation and Information</li> </ul>	<ul style="list-style-type: none"> <li>• Information Analysis and Management, Exercise</li> <li>• Exercise on Computational Science A</li> <li>• Information and Intellectual Property</li> <li>• Information Security</li> <li>• Artificial Intelligence, Advanced</li> </ul>

■ Contact Yoshida Honmachi, Sakyo, Kyoto 606-8501 Research Building #12, Rooms 110, 112

E-mail : [iedu@i.kyoto-u.ac.jp](mailto:iedu@i.kyoto-u.ac.jp)

## The Kyoto University ICT Collaboration Promotion Network

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

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

### ■ Kyoto University ICT Innovation

The main purpose of the annual event is to promote industry-academia matching. Faculty, researchers, graduate students, etc. of the Graduate School of Informatics, Academic Center for Computing and Media Studies, and Kyoto University School of Platforms present their research and development work related to information and communication technologies (ICT) in the form of posters and demonstrations. Participants present research focusing on concrete results, particularly software and contents, and also introduce industry-government-academia partnership activities.

The event will also be organically linked to guidance

for job seekers.

The event is supported by Kyoto Prefecture, Kyoto City, and other local government organizations, with the aim of making it more accessible to the general public.

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

### ■ Coordination of Industry-Academia Collaboration

#### 1. Industry → Academia

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

#### 2. Academia → Industry

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

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

A unique feature of this coordination is that the Collaboration Promotion Network Steering Committee systematically match all the labs of Graduate School of Informatics and the Academic Center for Computing and Media Studies with the relevant departments of the approximately 100 member companies of the network. This has already led to the launch of a completely new type of collaborative research project.

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

Kyoto University Original Co., Ltd. mail : [ictrenkei@kyodai-original.co.jp](mailto:ictrenkei@kyodai-original.co.jp)

## Request for Donations to the Fund

### ■ Graduate School of Informatics Fund

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

Generating new ideas and innovations that will support our future society requires the ability to think

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

### ■ Use of the Fund

- **Supporting the study and research of graduate students, honoring award**

Providing scholarships, mainly for doctoral students

Providing opportunities to send students to study at other universities, research institutes, etc. overseas or in Japan

Honoring graduate students who have carried out outstanding activities

- **Supporting young researchers**

Providing opportunities to send young researchers to overseas universities or research institutions for medium to long periods

- **Supporting research**

Supporting the work of researchers affiliated with Graduate School of Informatics

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

- **Supporting extracurricular activities and community service related to informatics**

Supporting extracurricular activities and community service carried out by individual students and groups enrolled at Kyoto University related to informatics, such as the International Collegiate Programming Contest (ICPC) and high school-university partnerships

### ■ Benefits for donors

- Receiving PR information about Graduate School of Informatics
- Receiving information on academic events organized by Graduate School of Informatics
- Names of donors are included in PR materials of Graduate School of Informatics
- Priority when registering for lectures, networking parties, or other events organized by Graduate School of Informatics (when places are limited)

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

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

### ■ Donation can be made here.





Kyoto University Graduate School of Informatics  
Yoshida-honmachi, Sakyo-ku, Kyoto 606-8501 JAPAN  
E-mail : 140soumu@mail2.adm.kyoto-u.ac.jp  
URL : <https://www.i.kyoto-u.ac.jp/>

