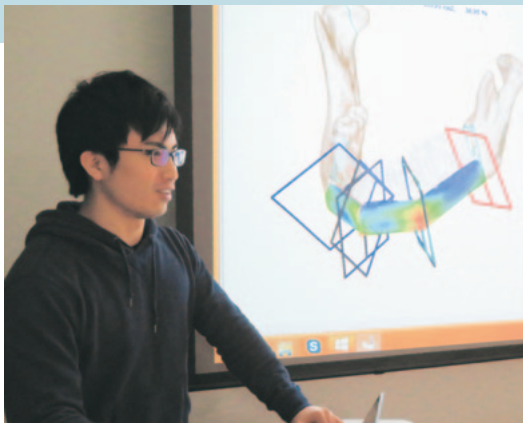
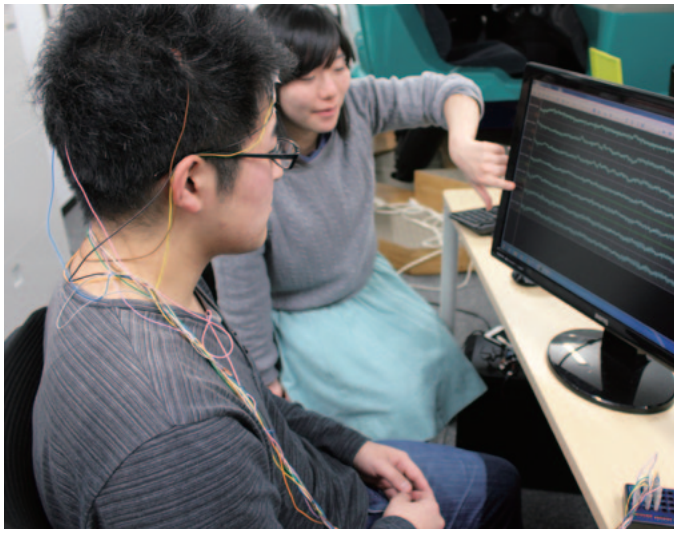
Department of Systems Science

New Frontier in Informatics and Systems

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



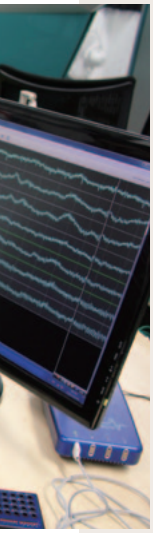


Information System Used in Medical Science and Treatment

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

MATSUDA Tetsuya
Department of Systems Science

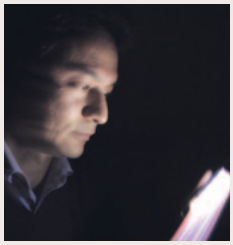
1981 Faculty of Medicine, Kyoto University, M.D. 1988 Graduate School of Medicine, Kyoto University, Ph.D. After working at Third Division, Department of Internal Medicine, Kyoto University Hospital, Division of Cardiovascular Disease, University of Alabama at Birmingham, and Department of Medical Informatics,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



Systems Science is Interesting!

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

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



TANAKA Toshiyuki
Department of Systems Science

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

Outline

Divisions and Groups

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

Graduate Curriculum

Courses for the Master's Program

Control Theory for Mechanical Systems
Theory of Human-Machine Systems
Modeling and Problem-Solving of Complex Systems
Theory of Symbiotic Systems
Adaptive Systems Theory
Statistical Systems Theory
Theory of Information Systems
Theoretical Life-Science
Medical Information Systems
Supercomputing (Advanced)
Advanced Study in Systems Science 1
Industrial Mathematics and Design
Advanced Study in Systems Science 2
Systems Sciences 1 (Advanced)
Systems Sciences 2 (Advanced)

Courses for the Doctoral Program

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

Teaching Staff

(M) : Academic Center for Computing and Media Studies

Professors

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

Associate Professors

AZUMA Shun-ichi; NISHIHARA Osamu; HAYASHI Kazunori; MASUYAMA Hiroyuki; NAKAO Megumi; FUKAZAWA Keiichiro (M)

Senior Lecturers

OBA Shigeyuki

Assistant Professors

MARUTA Ichiro; FUJIWARA Koichi; HIRAOKA Toshihiro; OHZEKI Masayuki; MAEDA Shin-ichi; HIRAISHI Tasuku (M)

Human Machine Symbiosis

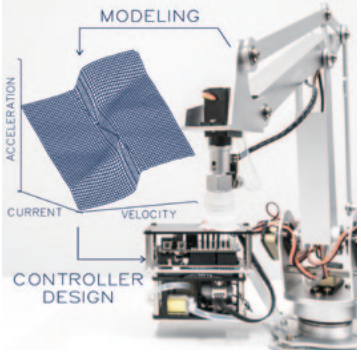
As computer networks spread and information systems become more sophisticated, the interrelationship between manmade systems (typified by machines) and humankind and the environment (including the natural environment and our social environment) is becoming ever more complicated and diverse. So we aim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

Mechanical Systems Control

Aiming to design robust and flexible mechanical systems

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

[Professor: SUGIE Toshiharu, Associate Professor: AZUMA Shun-ichi, Assistant Professor: MARUTA Ichiro]



A robot arm with 7 degrees of freedom

Human Systems

Aiming to Develop Human-Centered System Design Methodology

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

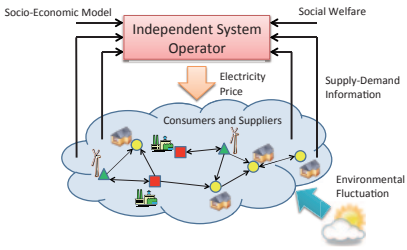
[Professor: KANO Manabu, Associate Professor: NISHIHARA Osamu, Assistant Professor: FUJIWARA Koichi]


Driver's EEG and ECG analysis

Integrated Dynamical Systems

Toward harmonious coexistence of a diversity of systems

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



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

Outline

System Synthesis

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

Adaptive Systems Theory

Theoretical approaches to systems that learn and adapt

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

[Professor: TANAKA Toshiyuki, Assistant Professor: OHZEKI Masayuki]

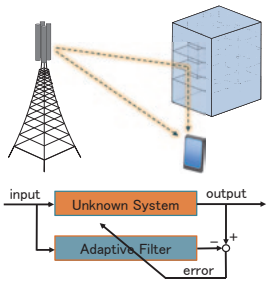
Digital communications as data mining: How one extracts the desired information from many intermixed signals is the key to high-performance digital communications.

Mathematical System Theory

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

Our research and teaching involve the building and analysis of mathematical models that can be applied to stochastic and statistical problems that appear in various systems, and the development of effective algorithms needed for the practical application of these solutions in the real world. Current research projects include time-series analysis, various adaptive algorithms for digital signal processing, and applications of the analytical approaches to wireless or wired communications systems.

[Associate Professor: HAYASHI Kazunori]



General framework for adaptive filters

Computational Intelligence Systems Adjunct Unit

Data Mining & Pattern Recognition Based on Statistical Machine Learning

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

[Professors: UEDA Naonori and TANAKA Toshiyuki]

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

Systems Informatics

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

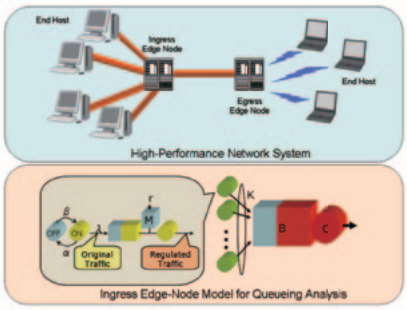
Information Systems

Developing advanced design methodologies for information systems

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

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

[Professor: TAKAHASHI Yutaka, Associate Professor: MATSUYAMA Hiroyuki]



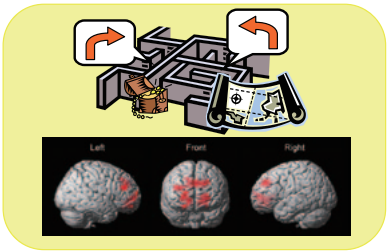
Theoretical model for the analysis of highspeed network systems

Integrated Systems Biology

Constructing models of information processing in life and intelligent systems

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

[Professor: ISHII Shin, Senior Lecturer: OBA Shigeyuki, Assistant Professor: MAEDA Shin-ichi]



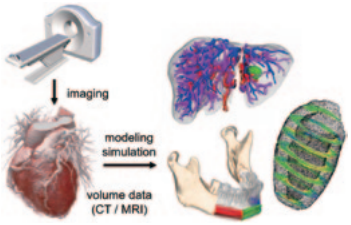
A model of the decision-making process in an uncertain environment, and images of information processing within the brain

Biomedical Engineering

Learning about the functions and physical characteristics of human bodies

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

[Professor: MATSUDA Tetsuya, Associate Professor: NAKAO Megumi]



Medical image processing and modeling for diagnosis and treatment

Outline

Computational Neuroscience Adjunct Unit

Create a brain in order to understand the brain

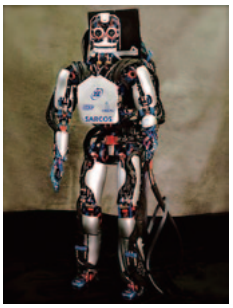
(a) Humanoid Robot

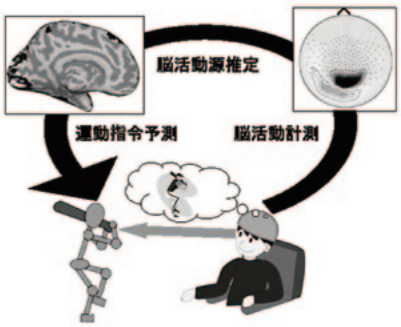
The goal of our study is to control robots by thoughts in the brain. This study is expected to contribute to the connection of humans and robots as a future telecommunication device and to the development of an assistive device for the recovery of motor functions in humans. We aim to understand brain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

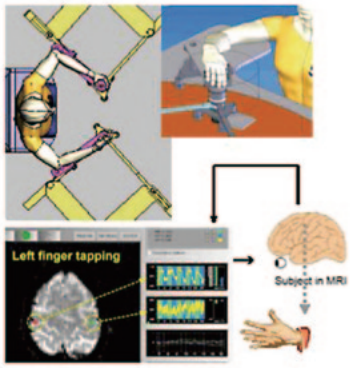
(b) Brain Machine Interface

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

[Professors: KAWATO Mitsuo and ISHII Shin]



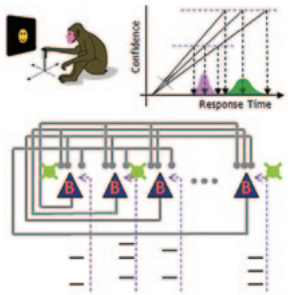




Neural Circuit Information Processing

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

[Professors: FUKAI Tomoki and ISHII Shin]

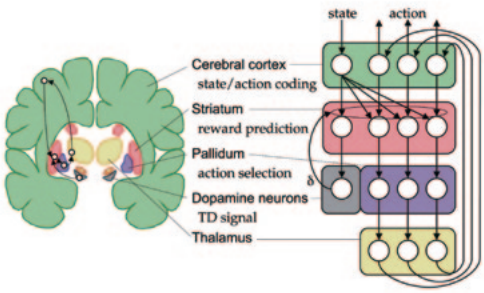


A neuronal network model for perceptual decision making inferred from activity of the monkey brain

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

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

[Professors: DOYA Kenji and ISHII Shin]



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

Applied Informatics (Affiliated)

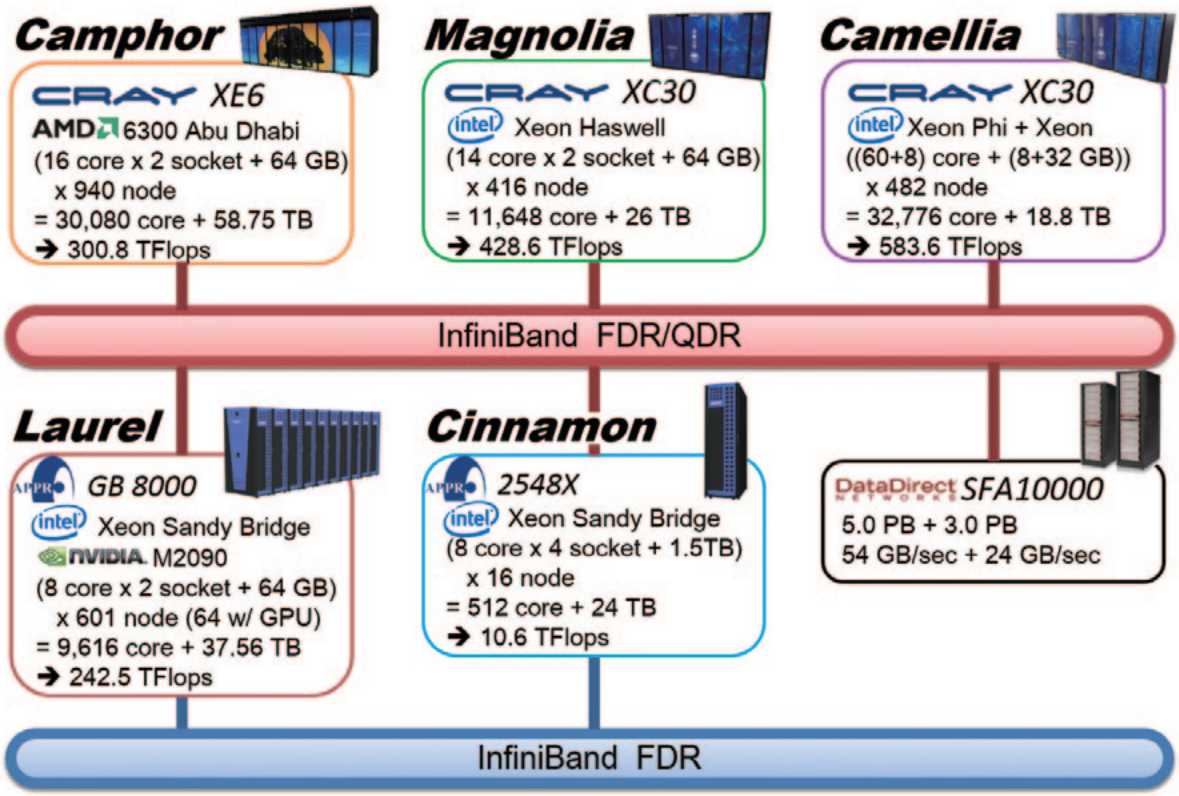
(Academic Center for Computing and Media Studies)

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

[Professor: NAKASHIMA Hiroshi, Associate Professor: FUKAZAWA Keiichiro
Assistant Professor: HIRAISHI Tasuku]

Aiming to be at the forefront of computing performance

We are involved in research into supercomputers, their software, and systems that are thousands or tens of thousands of times more powerful than ordinary personal computers. We are studying the basic technologies for high-performance parallel processing, such as parallel systems that link together many computers, languages that simplify parallel processing, and software libraries that can be widely used in a range of fields. Much of this research is in the form of joint research projects that extend beyond the field of computer science to involve researchers in the fields of medicine, physics, engineering, and other areas.



Supercomputer System in ACCMS