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

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

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

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

MATSUYAMA Takashi, Department of Intelligence Science and Technology

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

Courses for the Master's Program
- Introduction to Bioscience
- Introduction to Information Science
- Seminar on Biological Information Processing
- Foundation of Software Science
- Artificial Intelligence (Advanced)
- Multimedia Communication
- Language Information Processing (Advanced)
- Visual Interaction
- Advanced Research in Intelligence Science and Technology
- Advanced Study in Intelligence Science and Technology I

Courses for the Doctoral Program
- Advanced Seminar on Biological and Cognitive Processing
- Advanced Seminar on Intelligence Information Processing
- Advanced Seminar on Intelligence Media
- Advanced Seminar on Gene Informatics

Advanced Study in Intelligence Science and Technology II

Teaching Staff

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

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

Senior Lecturers
- HOSOKAWA Hiroshi
- MIYAZAKI Shuichi
- SHIBATA Tomohide
- KAWAHASHI Hiroaki
- NOBUHARA Shohei

Assistant Professors
- MAEGAWA Shingo
- SASAOKA Takafumi
- NAKAZAWA Koji
- YOSHINAKA Ryu
- OHMOTO Yoshimasa
- ITOYAMA Katsutoshi
- NISHIDE Shun
- TUNG, Tony (M)
- ICHINOSE Natsumi
- FUNATOMI Takuya (M)
- AKITA Yuya (M)
- HAYASHIDA Norihiko (Institute for Chemical Research)

(M) : Academic Center for Computing and Media Studies
Biological and Cognitive Processing

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

Biological Information

The Basis of Biological Information—

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

Cognitive Science

Towards a systematic understanding of the human brain—

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

Hearing and Speech Processing Adjunct Unit

Exploring speech production and reception mechanisms—
[in collaboration with the Advanced Telecommunications Research Institute International (ATR) ]

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

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

Foundation of Software Science

—Data Analysis That Matters—

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

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

Intelligence Information Processing Principles

—Formulation of principles to support intelligent information processing—

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

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

Applied Intelligence Information Processing

—Design and understanding of social intelligence and interaction—

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

Our research activities are grouped into three branches. The first focuses on interaction measurement, analysis and modeling. Major topics are IMADE (real world Interaction Measurement, Analysis and Design Environment), interaction mining, and CEBE (Capture and Express human Behavior Environment by using immersive environment). The second focuses on intelligent interactive systems. Major topics are GECA (Generic Embodied
The Intelligence Media Division deals with language, speech, and visual information, which are the fundamental media that represent, accumulate and communicate information. Research and education conducted at the Division cover a wide range of topics in theory and application, including analysis, recognition and understanding of information contents represented in these media, as well as media generation/editing to effectively represent and communicate information.

**Language Media Processing**

-Making computers that can understand language-

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

-Fundamental Studies on Text Understanding-

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

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

We have been developing a next-generation infrastructure of information retrieval on the basis of the following techniques of deep natural language processing: precise processing based not on words but on predicate-argument structures, identifying the variety of linguistic expressions and providing a bird’s-eye view of search results.

-Studies on Improving Machine Translation-

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

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

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

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

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

Visual Information Processing

—Towards systems that understand visual information—

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

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

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

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

(Professor: KUMADA Takatsune, Assistant professor: ICHINOSE Natsuhiro)

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**Application of Multimedia (Affiliated)**

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

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**Video Media**

—Human-computer interaction through video media—

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

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

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

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**Network Media**

—Towards a ubiquitous networking world—

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

(Professor: OKABE Yasuo, Associate Professor: MIYAZAKI Shuichi)
Bio-system Informatics (Affiliated)

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

Biological Information Networks

—IT for analysis of biological information—

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

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