2021 Admission Guide

Department of Information Physics and Computing

Graduate School of Information Science and Technology,

The University of Tokyo

Master’s Program

Doctoral Program

Contact [Department Administration Office]

7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656

Department administration office (Department of Information Physics and Computing), Graduate School of Engineering / Information Science and Technology Administrative Group,

The University of Tokyo

TEL: +81 (0)3-5841-6889

office@office.keisu.t.u-tokyo.ac.jp

Visit: https://www.i.u-tokyo.ac.jp/edu/course/ipc/index_e.shtml

In addition to this brochure, please be sure to review the application guidelines for the Graduate School of Information Science and Technology.
This document is a translation from the Japanese version.

I. Master’s Program

Based on the interdisciplinary nature of the Department of Information Physics and Computing, this Department seeks applicants from a wide range of fields, both inside and outside The University of Tokyo, with a fundamental understanding and knowledge of mechanics, electricity, physics, mathematics, and information. Examination subjects have been selected to ensure that applicants from diverse disciplines who are not students of The University of Tokyo can take the Examinations under conditions that are fair to all, with no priority or advantages offered to persons already registered at The University of Tokyo. As described in Section C, examinees can choose other subjects which are not conducted by this department in the specialized subjects.

A. Preference Card

Fill in boxes to the right of the names of the Faculty Advisors listed on the Preference Card (for Master’s Program) enclosed with this Guide, using numbers to order the preference up to nine choice or an ‘X’ if not preferred. When indicating your preferred field, please write a detailed description being as specific as possible. Your application will be rejected if you do not fall under the supervision of any of the particular Faculty Advisors you number or you keep empty. Submit the Preference Card together with the other application documents. The laboratories in this department conduct research closely together. Therefore, students can pursue cross-section studies about Information Physics and Computing in any laboratory.

B. Reason for Application and Research Plan for Master’s Program

Submit a three-page document describing the following contents either in Japanese or English:

(a) The reason for the application for the department of Information Physics and
Computing and the aspired research area with its reason.

(b) The research plan during the master’s program with a specific research theme and schedule and how that research contributes to our society, if necessary, with references.

The font size should be around 11 pt. The document should be on no more than three A4-sized pages for both (a) and (b). Figures can be included. Put your name on every sheet.

Since the above (a) and (b) are used for the document screening and to be scored, the document should include necessary and sufficient information.

It is not necessary to conduct the research described in the document after the entrance.

It is not always possible to conduct the research described in the document. The research theme during the master’s program is practically decided through discussion with your supervisor in the laboratory that you are assigned.

C. Examination Schedules

(Document screening)

Document screening will be conducted based on the submitted documents. Regarding the notification of the screening, refer to the Graduate School Application Guidelines.

(Written and oral examinations)

Written and oral examinations will be conducted for examinees who passed Document screening. Enrolled students will be selected by comprehensively using these results.

1. Regular education subjects

<table>
<thead>
<tr>
<th>Examination Date</th>
<th>Location</th>
<th>Examination Time</th>
<th>Examination Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 17, 2020 (Monday)</td>
<td>Faculty of Law and Letters Bldg. 2</td>
<td>10:00 – 12:30</td>
<td>Mathematics</td>
</tr>
</tbody>
</table>

Details on the Examination location will be delivered to every applicant by postal mail.
with an examination admission card and posted on the bulletin board at the main entrance of Bldg. 6 of the Faculty of Engineering at 9:00 a.m. on the day of the Examination.

TOEFL scores will be used to determine English ability. No written English Examination will be administered. For details, refer to “2021 Guidelines for Submission of TOEFL Scores; Graduate School of Information Science and Technology, The University of Tokyo,” which is enclosed in the School Application Guidelines.

Those who were absent from the written exam are considered to have withdrawn from the entrance exam.

2. Specialized subjects

a) Written Examination

For Examinations on Specialized Subjects, students shall choose one subject from among the following: “Information Physics and Computing”, “Mathematical Informatics”, “Computer Science”, and “Information and Communication Engineering”. Please note that dates, times, and locations differ depending on the subject.
<table>
<thead>
<tr>
<th>Specialized Subjects</th>
<th>Examination Dates, Times, and Locations</th>
<th>Scope of Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Physics and Computing</td>
<td>August 17, 2020 (Monday) 14:00 – 16:00 Faculty of Engineering Bldg. 6</td>
<td>Students will be required to select and solve two of five problems: “signal processing”, “electronic circuits”, “control”, “computer systems”, and “dynamics.”</td>
</tr>
<tr>
<td>Mathematical Informatics</td>
<td>Please refer to the “Guide to Department Entrance Examinations” for the Department of Mathematical Informatics.</td>
<td></td>
</tr>
<tr>
<td>Computer Science</td>
<td>Please refer to the “Guide to Department Entrance Examinations” for the Department of Computer Science.</td>
<td></td>
</tr>
<tr>
<td>Information and Communication Engineering</td>
<td>Please refer to the “Guide to Department Entrance Examinations” for the Department of Information and Communication Engineering.</td>
<td></td>
</tr>
</tbody>
</table>

Details on the Examination location for “Information Physics and Computing” will be posted on the bulletin board at the main entrance of Bldg. 6 of the Faculty of Engineering at 9:00 a.m. on the day of the Examination. For information on Examination locations for “Mathematical Informatics,” “Computer Science,” and “Information and Communication Engineering,” please refer to the Admission Guide for the department in question.

Those who were absent from the written exam are considered to have withdrawn from the entrance examination.

b) Oral Examination

Between 9:00 a.m. and 6:00 p.m. on Tuesday, Thursday and Friday, August 18, 20, and 21, 2020.

Detailed schedules will be posted or distributed during the Examination period. The schedule of Oral Examination for examinees who take the subject of the written exam
other than “Information Physics and Computing” will be adjusted to avoid overlapping.

3. Guidance for Oral Examinations

<table>
<thead>
<tr>
<th>Date and Location</th>
<th>Time</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 17, 2020 (Monday) Faculty of Law and Letters Bldg. 2 or Faculty of Engineering Bldg. 6</td>
<td>After the completion of the Regular education subject, “mathematics,” examination</td>
<td>Guidance will be provided regarding all processes to be used during Oral Examinations.</td>
</tr>
</tbody>
</table>

D. Notes of Caution

1. Persons who have not graduated from university by August 2020 wishing to enter the school in September are required to confirm their eligibility with the Department Team (the Department of Information Physics and Computing), Academic Affairs Group, Graduate School of Engineering / Information Science, The University of Tokyo.

2. Please carefully read the “Useful information for persons taking Entrance Examinations (Master’s and Doctoral Programs),” which is included in this Admission Guide.
II. Doctoral Program

A. Persons wishing to apply to the Doctoral Program should refer to the “2021 Admission Guide: Doctoral Program, Graduate School of Information Science and Technology,” and must contact the persons named below before submitting the application. Please call or write well in advance.

Contact:
Department of Information Physics and Computing, Graduate School of Information Science and Technology, The University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656

Department of Information Physics and Computing Administration Office
+81 (0)3-5841-6889
office@office.keisu.t.u-tokyo.ac.jp

B. Preference Card

Indicate your preferences with regard to Faculty Advisors, etc., on the “Preference Card” (Doctoral Program) included with this Guide, and submit this card together with the application documents. Students admitted to the doctoral program carry out research under the guidance of a designated faculty member who serves as the student’s research and thesis advisor. Applicants must identify a faculty member with whom they propose to conduct their research and then contact the faculty member to arrange a face-to-face or online interview in which the applicant describes his or her academic achievements, research experience, research abilities, and research plans before submitting the
application form. The interview must be conducted from April 24, 2020 to June 1, 2020 for Summer Examinations or from October 15, 2020 to December 5, 2020 for Winter Examinations. Applicants may not be allowed to take the examinations if they fail to complete this procedure.

C. Outline of past research results and Research Plan for Doctoral Program

Submit the following reports together with the other application documents:

1. Describe the content and results of past research as well as the positioning of that research in the field in question. Summary should be in either English or Japanese, on no more than two A4-sized pages.

2. Provide a concrete plan for research to be conducted after admission to the Doctoral Program and describe how this research will contribute to the field in question. Summary should be in either English or Japanese, on no more than two A4-sized pages.

3. Provide the list of research achievement on A4-sized pages. Original articles, review articles, oral presentations, and others should be categorized. If there is no corresponding research achievement, describe as “not applicable”.

The above documents will be used as the basis for the Oral Examinations and subject to scoring. The documents are also used for preliminary screening for exemption from Oral Examination I, so please ensure to prepare these documents carefully in terms of length and content.

D. Examination Schedules

At the time of application, please select either the Summer Entrance Examination or the Winter Entrance Examination. Please note that the periods for acceptance of applications differ for the summer and winter Examinations.
1. Summer Examinations

(Primary Examinations)

<table>
<thead>
<tr>
<th>Examination Dates and Locations</th>
<th>Examination Times</th>
<th>Examination Subjects</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 17, 2020 (Monday) 15:00 –, or August 18, 2020 (Tuesday) 10:00 – Faculty of Engineering Bldg. 6</td>
<td>Detailed schedules will be posted at 10:00 on August 17.</td>
<td>Oral Examination I</td>
<td>Examinees will be required to answer questions related to the fundamentals of Information Physics and Computing and to the applicant’s research field.</td>
</tr>
<tr>
<td>August 20, 2020 (Wednesday) Faculty of Engineering Bldg. 6</td>
<td>Detailed schedules will be posted at 17:00 on August 19.</td>
<td>Oral Examination II</td>
<td>Examinees will be required to answer questions on their research results and research plan submitted beforehand.</td>
</tr>
</tbody>
</table>

TOEFL scores will be used to determine English ability. No written English Examination will be administered. For details, refer to “2021 Guidelines for Submission of TOEFL Scores; Graduate School of Information Science and Technology, The University of Tokyo,” which is enclosed in the School Application Guidelines.

Persons who have completed or are expected to complete The University of Tokyo Graduate School Master's Program will not be required to submit TOEFL scores. Also persons who have completed, are expected to complete a Master’s Program of Graduate School of Information Science and Technology in The University of Tokyo, or have passed the preliminary screening for exemption will exempt Oral Examination I.

Examinees who are rejected in Oral Examination I cannot take Oral Examination II. The passing status of Oral Examination I will be posted with the schedules of Oral Examination II.

(Secondary Examinations)
As a rule, Secondary Examinations will be conducted during the period from late January to mid February, 2021. Applicants will be notified later regarding details of schedules and locations. Applicants should bring their Master’s thesis (or some equivalent material) to the Secondary Examinations. For persons wishing to start school in September and for persons already holding a master's degree at the time of application, the Secondary Examination will be conducted based on the schedule for the Oral Examinations II.

2. Winter Examinations

As a rule, primary and secondary Examinations will be conducted during the period from late January to mid February, 2021. Acceptance will be limited to a few students. Examination methods will be in accordance with those used for Summer Examinations. Applicants will be notified regarding details of schedules and locations after applications have been received.

E. Notes of Caution

1. Persons wishing to start school in September 2020 but have not been conferred Master’ degree by August 2020, are required to confirm their eligibility with the Department Team (the Department of Information Physics and Computing), Academic Affairs Group, Graduate School of Engineering / Information Science, The University of Tokyo.

2. Persons wishing to be included in the “Special Selection for Professionals” MUST contact the Administration Office described above before submitting the application. Additional documents will be needed for the “Special Selection for Professionals.”

3. Please carefully read the “Department of Information Physics and Computing, Graduate School of Information Science and Technology, The University of Tokyo: Useful information for persons taking Entrance Examinations (Master’s and Doctoral Programs),” which is included in the Admission Guide.
Useful information for persons taking Entrance Examinations
(Master’s and Doctoral Programs)

1. Examination dates and times

Please refer to the “Examination schedules” listed in this Guide.

2. Examination locations

By subway:

Marunouchi Line / Oedo Line: Get off at Hongo-sanchome Station
Chiyoda Line: Get off at Nezu Station
Namboku Line: Get off at Todaimae Station
Mita Line: Get off at Kasuga Station

(a) Specified Examination rooms are subject to change depending on the number of examinees. Please confirm all locations on the bulletin board at the main entrance to Bldg. 6 of the Faculty of Engineering on the day of the Examination.

(b) Examinees should be in the designated Examination room no later than 15 minutes before the scheduled start of the Examination.

3. What to bring

(a) Examination admission card;

(b) Black pencils (mechanical pencils are OK);
(c) Erasers;
(d) Pencil sharpener (only the small, handheld, non-electric type is acceptable);
(e) Clock or watch (for showing time only; devices with other functions are not acceptable).

No writing implements or tools other than those noted above will be allowed during written Examinations.

Caution: During the Examination period, all mobile phones must be turned off. Mobile phones must also not be carried on the examinee’s person (on neck straps, in pockets, etc.).

4. Items to keep in mind during Examinations

(a) Examinees will not be allowed to leave the Examination room during the Examination period.

(b) Examination admission cards must be kept on the desktop throughout the entire Examination period.

(c) Examinees must write their examination admission number. Examinees must not write your name. Examinees must write each answer on the designated sheet. If there is not enough space, examinees may write on the back of the answer sheet.

(d) Examinees cannot take answer sheets or question booklets out of the Examination room.
Access Map to Examination Location

By subway:

- Marunouchi Line / Oedo Line: Get off at Hongo Sanchome Station
- Chiyoda Line: Get off at Nezu Station
- Namboku Line: Get off at Todai Mae Station
- Mita Line: Get off at Kasuga Station

Bus:

Take Toei Bus No. 43 or 51 to “Todai Seimon Mae” (Main Gate of The University of Tokyo), or Toei School Bus No. 1 or 7 to “Todai Konai” (Campus of The University of Tokyo).
<table>
<thead>
<tr>
<th>Program</th>
<th>Master's Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examinee's name</td>
<td>Examination admission number (leave blank)</td>
</tr>
<tr>
<td>Graduating university (only if applicable)</td>
<td>University / School / Department:</td>
</tr>
<tr>
<td>Phone number and e-mail where examinee can be contacted during the Examination period</td>
<td>Address: Tel: Mobile phone:</td>
</tr>
<tr>
<td>Preferred Faculty Advisor (in order of preference)</td>
<td></td>
</tr>
<tr>
<td>Prof. Hiroshi Saruwatari</td>
<td>Prof. Hiroshi Nakamura</td>
</tr>
<tr>
<td>Shoichi Koyama (Lecturer)</td>
<td>Associate Prof. Masaaki Kondo</td>
</tr>
<tr>
<td>Prof. Kenji Kawashima</td>
<td>Masashi Ikeuchi (Lecturer)</td>
</tr>
<tr>
<td>Prof. Takaaki Nara</td>
<td>Prof. Masahiko Inami</td>
</tr>
<tr>
<td>Keisuke Hasegawa (Lecturer)</td>
<td>Prof. Hiroshi Saito</td>
</tr>
<tr>
<td>Prof. Hiroyuki Shinoda</td>
<td>Atsushi Hiyama (Lecturer)</td>
</tr>
<tr>
<td>Associate Prof. Yasutoshi Makino</td>
<td>Prof. Yuji Sekiya</td>
</tr>
<tr>
<td>Prof. Masayuki Fujita</td>
<td>Prof. Hiroki Ueda</td>
</tr>
<tr>
<td>Associate Prof. Koji Tsumura</td>
<td>Associate Prof. Takahiro Shinagawa</td>
</tr>
<tr>
<td>Prof. Makoto Naruse</td>
<td></td>
</tr>
<tr>
<td>Specialized subjects to be tested on the Examination (Please circle the appropriate responses)</td>
<td>Information Physics and Computing / Mathematical Informatics / Computer Science / Information and Communication Engineering</td>
</tr>
<tr>
<td>Preferred start date (Please circle the appropriate response)</td>
<td>September 2020 / April 2021</td>
</tr>
<tr>
<td>Residence Card Status: student / other( )</td>
<td>Retain / Not Retain</td>
</tr>
<tr>
<td>Expiration date:</td>
<td></td>
</tr>
</tbody>
</table>

Submit this form together with your application. Persons who have not graduated from university by August 2020 wishing to enter the school in September are required to confirm the eligibility with the Department Team (the Department of Information Physics and Computing), Graduate School of Engineering / Information Science and Technology, Academic Affairs Group, The University of Tokyo, and circle “September 2020” in the appropriate column above.
Submit a three-page document describing the following contents in Japanese or English:

(c) The reason for the application for the department of Information Physics and Computing and the aspired research area with its reason.

(d) The research plan during the master’s program with a specific research theme and schedule and how that research contributes to our society, if necessary, with references.

The font size should be around 11 pt. The document should be on no more than three A4-sized pages for both (a) and (b). Figures can be included. Put your name on every sheet.

Since the above (a) and (b) are used for the document screening and to be scored, the document should include necessary and sufficient information.

It is not necessary to conduct the research described in the document after the entrance. It is not always possible to conduct the research described in the document. The research theme during the master’s program is practically decided through discussion with your supervisor in the laboratory that you are assigned.
### Program

<table>
<thead>
<tr>
<th>Program</th>
<th>Doctoral Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examinee’s name</td>
<td>Examination admission number (leave blank)</td>
</tr>
<tr>
<td>Graduating university or graduate school</td>
<td>University:___________________</td>
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<td>School:___________________</td>
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<td>Department:___________________</td>
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<td>Graduate School:___________________</td>
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<td></td>
<td>School:___________________</td>
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<tr>
<td></td>
<td>Department:___________________</td>
</tr>
<tr>
<td>E-mail and phone number where examinee can be contacted during the Examination period</td>
<td>Address:</td>
</tr>
<tr>
<td></td>
<td>Tel:</td>
</tr>
<tr>
<td></td>
<td>E-mail:</td>
</tr>
<tr>
<td>Preferred Faculty Advisor</td>
<td>Advisor:</td>
</tr>
<tr>
<td>Application Category</td>
<td>SUMMER Entrance Examination / WINTER Entrance Examination</td>
</tr>
<tr>
<td>Preferred time of entry (Please circle the appropriate response)</td>
<td>September 2020 / April 2021</td>
</tr>
<tr>
<td>Residence Card</td>
<td>□ Retain Status: student / other( )</td>
</tr>
</tbody>
</table>

### Outline of past research results and Research Plan for Doctoral Program

Submit the following reports together with the other application documents.

1. Describe the content and results of past research as well as the positioning of that research in the field in question. Summary should be in either English or Japanese, on no more than two A4-sized pages.
2. Provide a concrete plan for research to be conducted after admission to the Doctoral Program and describe how this research will contribute to the field in question. Summary should be in either English or Japanese, on no more than two A4-sized pages.
3. Provide the list of research achievement on A4-sized pages. Original articles, review articles, oral presentations, and others should be categorized. If there is no corresponding research achievement, describe as “not applicable”.

The above documents will be used as the basis for the Oral Examinations and subject to scoring. The documents are also used for preliminary screening for exemption from Oral Examination I, so please ensure to prepare these documents carefully in terms of length and content.

- Submit this form together with your application.
- Please note that the periods for acceptance of applications differ for the summer and winter Examinations. Application documents that arrive outside of the applicable period for acceptance of applications shall be deemed invalid.
- Persons who have not earned Master’s degree by August 2020 wishing to enter the school in September via the Summer Examination are required to confirm the eligibility with the Department Team (the Department of Information Physics and Computing), Graduate School of Engineering / Information Science and Technology, Academic Affairs Group, The University of Tokyo, and circle “September 2020” in the appropriate column above.
Faculty members and laboratories
Sound Media Informatics Lab. (Saruwatari and Koyama Lab.)
http://www.sp.ipc.i.u-tokyo.ac.jp/
This laboratory mainly addresses an innovation in new signal processing and information processing systems, focusing our attention on understanding, processing, and control of sound media (speech, music, etc.). For example, theories on new statistical modeling and machine-learning-based algorithms are of interest for us to solve the optimization problems under acoustical generative models and physical constraint. Through the innovation, we realize expansion of human hearing systems, new man-machine interface systems as well as new contribution to music art creation.

(1) Auditory Communication Augmentation via Unsupervised Learning

We realize versatile unsupervised source separation combining statistical estimation theories and low-rank modeling. Also, we address a new harmony of deep learning and spatial acoustics, which can be applied to semi-supervised source separation. Thanks to these methods, new man-machine human interface, auditory communication augmentation system, and user-oriented music information system can be developed.

(2) Inverse Problems for Acoustic Field, Sound Field Control, and Their Applications

We tackle with inverse problems for acoustic field, such as sound field imaging, analysis, source localization, and estimation of room acoustic parameters, and sound field control problems for reproducing a desired sound space. We explore new methodologies with various approaches (signal processing, optimization, statistical modeling, machine learning, etc.) and develop new systems for telecommunication, virtual reality, and so on.

(3) Augmented Speech Communication Based on Machine Learning

We address signal processing and machine learning theories for speech synthesis and conversion towards human-human and human-machine communication. We interpret speech from perspectives of physics and informatics and deal with accurate modeling of speech signals and speech information. We also develop speech-based virtual reality systems by human-in-the-loop speech modeling that integrate humans into machine learning.

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1) Department of Creative Informatics
<table>
<thead>
<tr>
<th>Professor Kenji Kawashima</th>
</tr>
</thead>
</table>

We research and develop novel medical systems, robot systems, and human-machine systems that are useful for realizing a healthy longevity society, such as surgical support and motion assistance. Our original technique is to combine the measurement control technology based on distributed parameter models of fluid drive systems with the system design that utilizes actuator characteristics. Also, we integrate medical engineering and information science to develop highly intelligent and functional systems, and we will implement them into our society.

(1) Surgical assist robots

We are researching robots that assist in minimally invasive surgery. We aim to improve system intelligence and function by autonomous control of some operations using machine learning, and we improve the safety of surgery by showing multimodal information to the operator.

(2) Motion assist systems

By utilizing the advantages of direct-drive of soft actuators such as pneumatic artificial rubber muscles, we realize motion assistive systems that estimate a wearer’s motion from control information on the actuator without mounting sensors on the wearer’s body.

(3) Measurement and control of fluid systems

We propose applications to state estimation and prediction problems in fluid-driven medical systems by using morphological computation that utilize non-linearly distributed state quantities of the fluid-driven systems.
Inverse problems are recovering problems of physical information from indirect measurements with mathematical reconstruction. Our laboratory develops basic and unified theories and measurement/actuating systems for the inverse problems.

(1) Development of direct reconstruction and measurement methods for inverse problems: for inverse source/coefficients/boundary value/governing-equation problems, theories to express physical information in a closed form in terms of data are developed based on mathematical physics such as complex analysis, potential theories, and tensor analysis.

(2) Application to non-invasive measurements, non-destructive inspection, and disaster relief: novel measurement and mathematical methods are developed and applied to diagnosis of epilepsy based on magnetoencephalography (MEG) and electroencephalography (EEG), imaging of electrical and mechanical properties inside the human body based on magnetic resonance imaging (MRI), non-destructive testing using electromagnetic field and ultrasonic waves, and search for victims buried in rubble in earthquake disasters.

(3) Construction of physical information systems based on midair acoustic fields designed via inverse-problem formulation: airborne acoustic fields with desired spatiotemporal structures are designed by solving inverse problems derived from physical models, so as to realize novel functions such as remote airflow control, non-contact acoustic measurement, and midair pinpoint communication.
We realize a real-world informative environment that goes beyond conventional barriers by introducing new physical phenomena and physical structures into the system. In particular, we propose technologies from hardware to applied systems for sensing humans, environments, and their interactions, and for supporting humans through haptic and other human senses. Research topics include basic and universal discoveries based on novel ideas and the process of solving social problems and using them as practical technologies.

(1) Haptic Interface: A system that supports human life and behavior by stimulating the sense of touch simultaneously with audiovisual information. Clarify the relationship between the tactile sensation and the mind and emotion that support the base of human intelligence, and apply it to real systems.

(2) 2D Communication: Transmits information and electricity through a thin sheet using electromagnetic waves to realize wireless power supply and high-speed signal transmission without interfering with conventional wireless LAN.

(3) Use of human behavior: Based on the features in human behavior, we predict near-future motion and estimate haptic characteristics of the object in touch. This technology can be used for preventing fall out and for sports.

(4) Other topics such as physical informatic devices, human-machine interfaces, non-contact measurement of haptic information, artificial robot skin, wearable computing, etc.
Control and Autonomy in Cognitive Cyber-Physical Systems

(1) Cooperative Control in Networked Robotics
We are conducting research on cooperative control of networked multi-robot and multi-agent systems. Our goal is to explore the fundamental principles for designing totally optimal motions from distributed information exchanges.

(2) Autonomy in Cognitive Cyber-Physical Systems via ML/AI-based Control
We are studying autonomous systems which can make a decision on their motion by environmental perception and cognition. Our goal is to create a novel control theory which realizes robust and intelligent action via learning of uncertainties in systems and environments.

(3) Cyber-Physical & Human Systems
We are working on cyber-physical systems with human interventions in decision-making. In particular, our interest is on a system design for realizing Human-Machine Teamings.
Control engineering is for design of behavior of systems and we aim to develop its theories and applications widely. The research themes are divided into three categories: cybernetics, control system analysis & synthesis, and modeling/system identification/estimation/learning, which are explained below:

1. Cybernetics: By employing new fusion of system control theory with information theory/physics/optimization/system biology, we aim to establish theories of analysis and synthesis for large scale complex system/multi-agent system/networked system/networked AI/bio-system/quantum control system.

2. Control System Analysis & Synthesis: We aim to develop advanced control theories including robust control, nonlinear control, hybrid control, learning control and so on.

3. Modeling/System Identification/Estimation/Learning: We aim to establish theory for modeling of dynamical systems, in particular, system identification for uncertain modeling or modeling for large-scale complex systems.
We are exploring the frontier of constructing emerging functionality, such as innovating computing, decision making, etc., with particular emphasis on the significance of intertwining natural processes in nature with artificially constructed devices and systems. Parts of current projects are outlined in the following, but we are always welcoming exciting new initiatives.

(1) AI Photonics – Decision Making by Photons—

This project physically resolves decision making problems, which is one of the most important elements in information and communication technology (ICT) including artificial intelligence (AI), by utilizing the unique physical nature of photons. The topic will include the design of novel principles, applications, among others.

(2) Architectural Fundamentals for Functional Systems

The extensive progress of ICT and AI imposes further demands to optics and photonics while the emergence of new physical layer technologies require novel design of system architectures. We will explore innovative architectures such as arbitration-free information networks by precision timing synchronization technologies.

(3) Natural Computing / Natural Transformation Design

Toward developing computing using natural processes, theoretical fundamentals are important, which is also the key concept of our Department highlighting the significance of intertwining the real physical world and cyber world. For such purposes, we will explore the concept and the design fundamentals, what we call “Natural Transformation Design” by utilizing modern mathematics including category theory as well as model theories based on empirical findings.
In order to realize effective interaction between the cyber and the physical world, we focus on high quality computing in various aspects including high performance, low power, dependable, secure, and comfortable computing. The detailed research themes are shown below.

(1) **Cognitive computing**: Cognitive computing or AI technology in which computers learn, perceive, and make a decision by themselves, has recently been paid much attention in many areas. This topic focuses on AI hardware architecture and algorithm design for the object recognition and anomaly detection, and novel reinforcement learning techniques.

(2) **Graph processing framework for smart society**: Graph processing is a powerful tool for modeling and optimizing complex problems such as analysis of relationships among things and movement tracking of them. We are conducting research on an efficient architecture and edge-cloud cooperation for graph processing frameworks and its application to robot intelligence.

(3) **IoT / cyber physical / Secure systems**: Internet of Things (IoT) enables us to collect, aggregate, and utilize a huge amount of data generated by all sorts of things via the Internet. It is a crucial requirement to process massive data processing under a secure environment by novel control of edge devices. Research on system design methodologies and application development for secure IoT and cyber physical systems are the main themes of this topic.

(4) **Normally-off computing**: Toward ultimate low-power computing, we have been proposing a concept of Normally-off computing where inactive components of computer systems are aggressively powered off with the help of non-volatile memories which can preserve information at the powered-off state. The research topic is a computer system design based on this novel concept.

(5) **Cryogenic computing**: Novel computing principles and systems based on the superconducting devices in cryogenic environment are becoming crucial technologies. We are researching new computer systems with the single flux quantum technology and its application to control logic for quantum computers.
We are exploring to understand and control biomedical processes by using microsystem engineering, such as minimally invasive medical devices and microscale cell analysis devices based on micro/nano fabrication and manipulation technologies.

(1) Microrobotic System for Assisted reproductive technology

In recent years, the number of cases of assisted reproductive technology has increased rapidly in the world. However, the process from ovum collection and sperm collection to pregnancy has many medically unexplained steps, causing the success rate of the treatment to be kept around 30%. We aim to improve the overall success rate of assisted reproductive technology by using microrobots and microfluidic devices while studying the biological mechanism of the processes.

(2) On-chip Cell Processing for Regenerative Medicine

Low-cost mass-production and quality assurance technology of cells and tissues is indispensable for the spread of regenerative medicine. In contrast to the conventional robotic cell processing technology, we utilize micro-fluidics technology to realize a benchtop regenerative medicine factory by eliminating compatibility with traditional manual experiment.

(3) Minimally Invasive Treatment System Based on Mechanobiology

We elucidate how cells and tissues sense and respond to mechanical stimuli at the single-cell level by using improvised microscale cell manipulation devices. Moreover, based on the cellular response to mechanical stimulation, we are developing new minimally invasive medical treatment without using drugs.
Information Somatics Lab. (Inami and Hiyama Lab)

https://www.star.rcast.u-tokyo.ac.jp

Professor
Masahiko
Inami

Lecturer
Atsushi
Hiyama

Researches on “Information Somatics” is about supporting and augmenting innate functions of human such as sensory, motility, and intelligent processing. We investigate the mechanism of human body based on physiological, cognitive, and physical knowledge. We propose “JIZAI” technology that enables humans to manipulate their bodies freely with “Human-Computer Integrated” systems enhancing human I/O and using instruments or systems as if controlling their own bodies.

(1) JIZAI Technology

In order to design “Human-Computer Integrated” systems, we need to recognize users’ intentions and give proper feedbacks to their bodies. We enhance human I/O by integrating sensing technologies such as eye-gaze and electrical muscle detection; perception and prediction technologies like machine learning; actuation technologies such as multimodal information and electrical muscle stimulation.

(2) Developing New Body Schema and Social Implementation

We enhance human ability by applying VR, AR, wearables, robot, and telexistence. Through this effort, we investigate a way to acquire new body schema such as getting an extra body, without physical body, transformation, shadowing, integration, etc. We aim to implementing practical applications of our researches to the job assistance in the hyperaged society, Super-human sport project, etc.

(3) Experience and Memory Augmented and Transferred

We are developing systems recording, reproducing, and transferring subjective experience as information spreading physically and spatially, and designing artifacts for contributing to our experience and memory over a long period. The former will be used for transferring skills of craftsmen, and the latter will be applied for remembering and memorializing the deceased.
Professor
Hiroshi
Saito

Research Theme: Research on mathematical methods implementing advanced networks such as Internet of Things (IoT) and applications based on sensory data brought by them.

Implementing advanced networks such as IoT and application services based on sensory data brought by them needs a lot of mathematical methods. Research on those methods requires understanding both these mathematical methods and advanced networks/application services. Through the understanding of both of them, this laboratory is doing research on new applications of these methods to advanced networks and application services, and developing core algorithms of advanced network systems and application services.

Examples of research

(i) Using on-line weather information such as typhoons, our proposed disaster avoidance control relocates network function blocks on the network and cloud and substantially escape from disasters. Our proposed physical network design method provides geometrical and geographical shape of the network to minimize the possibility of encountering disasters. Such research aims at implementing “the disaster-free network.”

(ii) Sensors need to detect target objects in varieties of situations such as detecting intruders passing through a border and abnormal events within an area of interests. An optimal sensing area shape design method and an optimal sensor placement algorithm are studied to achieve the effectively detecting target objects.

(iii) There have been deployed many devices that have sensing capabilities such as smartphones. By analyzing sensory data from them as time-series data or as ensemble data, we are developing new applications such as health management, person identification, risk management.

3) Mathematics and Informatics Center
In this laboratory we research on communication infrastructure technology and its architecture using software and virtualization, and research on the methods for detection and countermeasures against cybersecurity threats using machine learning.

This laboratory cooperates with Information Technology Center and Security Informatics Education and Research Center in The University of Tokyo. We aim to contribute improving the system architecture using software technology and cyber security measures based on the actual operations.

(1) Virtualization and software technologies have been introduced as elemental technologies for information communication systems (ICT) such as cloud computing and 5G. In recent years, flexibility and promptness are required on a current ICT system. Therefore, virtualization and software technology are introduced in the architecture. In this laboratory, we research software technologies for ICT system and its new architecture.

(2) Nowadays, cyber security is a big problem for ICT systems. Attackers steal confidential information and hijack systems through organized and sophisticated attacks. In this laboratory, we research the methods to detect cyber threats using machine learning technologies with various types of datasets from communication infrastructure and social trends. This research improve the safety of ICT systems which support social infrastructures.

4) Security Informatics Education and Research Center
Our goal: Understanding and controlling sleep and consciousness through the integration of medicine and information science

Whole-brain & whole-cell analysis

Our laboratory developed a whole-brain clearing and imaging method (CUBIC), which can make brain sample transparent and all cells in the brain can be analyzed in a single-cell resolution includes positional information of all cells. Aiming at understanding brain functions, we will develop analysis and visualization methods for large image data (14 terabytes per brain) obtained by CUBIC, and apply it to the study of sleep/wake rhythm.

Keywords: Cloud computing, Brain function analysis, Image analysis

Chemoinformatics-driven Drug discovery

Chemoinformatics has been increasing its importance in drug discovery research, but it still requires developments in many aspects such as activity prediction and structure prediction. In our laboratory, we will develop algorithms to predict drug discovery and experimental reagent candidates by predicting compounds with specific activities, and apply it to the study of sleep/wake rhythm.

Keywords: Machine learning, Bayesian optimization, Drug screening

Development of sleep classification algorithm using biological data

Accurate sleep classification of humans is performed by measuring brain waves. Based on time-series data that can be easily acquired, such as breathing and arm movements, we have developed a simple and high-performance sleep classification algorithm using machine learning. With improving this algorithm, we will analyze big data of sleep and understand sleep/wake rhythm.

Keywords: Machine learning, Time series analysis, Biological data

5) Department of Systems Pharmacology, Graduate School of Medicine
Our research is about low-layer (deep) system software located on the boundary between computer hardware (physical world) and software (information world).

We primarily focus on core system software such as operating systems (OS) and virtual machine monitors (VMM) but also cover system software in general from middleware to distributed systems. From the perspectives of performance, functionality, security, reliability, manageability, and abstraction, we are conducting leading-edge research and development that contributes to the realization of next-generation system software based on new concepts. We use existing OSes such as Linux, Windows, macOS, iOS, and Android, and our original virtualization software called BitVisor developed in our laboratory. The target hardware is a variety of computer systems from large-scale systems such as servers, clouds, and data centers to small systems such as desktops, smartphones, and embedded devices such as IoT devices.

1. Operating system: we are conducting researches to improve functionalities and performance based on existing OS kernels. We also aim to research and develop our own OS for next-generation computers.

2. Virtualization software: we have been conducting many kinds of research based on “BitVisor” made in Japan. By exploiting modern virtualization technology, we aim to realize new functionalities, such as security and system management, without depending on OSes.

3. Secure computing: we aim to provide a secure computing environment as a whole by combining OS kernels, virtualization software, compilers, and applications organically.
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