超スマート社会推進コンソーシアム
TokyoTech Super Smart Society Promotion Consortium

Smart Robotics

Smart Agriculture

Quantum Science

Smart Workplace

Smart Mobility

Super Smart Society Promotion Consortium

Activity Report

Artificial Intelligence

Smart Ocean

Smart Infrastructure Maintenance

Smart Building

2023

東京工業大学
Tokyo Institute of Technology

Table of Contents

Preface (Celebration of 5th Anniversary)

In 2018, the Tokyo Institute of Technology (Tokyo Tech) established the Super Smart Society Promotion Consortium with the aim of realizing a Super Smart Society (Society 5.0). In April 2020, Tokyo Tech collaborated with Consortium Partners to launch the WISE Super Smart Society Program (WISE-SSS Program). The consortium and program have been the driving force for Tokyo Tech's promotion of social collaborative education (open education) and attempting interdisciplinary research (open innovation) in collaboration with all related sectors, including local governments, private companies, and national research institutes participating in the consortium. Through these efforts, we have achieved education that combines cyberspace and physical space, and have built a wide range of research and education fields.

The consortium celebrated its fifth anniversary in 2023. In commemoration of this milestone, we held the "Super Smart Society Promotion Consortium 5th Anniversary Symposium" on March 13, 2024. The theme of the symposium was "What should we do now for the future human society?" At the symposium, we invited prominent key people from each field to introduce their cutting-edge knowledge and share their thoughts on DX, ICT, AI, agriculture, medicine, human resource development, future forecasting, SDGs, etc. from a big-picture perspective. The symposium was highly evaluated by many participants.

This year, Tokyo Tech will merge with Tokyo Medical and Dental University to embark on a new journey as the Institute of Science Tokyo (Science Tokyo). In conjunction with the merger, the Super Smart Society Promotion Consortium will also venture into medical and engineering collaboration fields such as smart healthcare. I look forward to seeing dramatic progress by the Super Smart Society Promotion Consortium.

Kazuya Masu
President, Tokyo Institute of Technology

The Tokyo Tech Super Smart Society Promotion Consortium celebrated its fifth anniversary after being established in 2018. The consortium was established as a new platform that connects Tokyo Tech students and faculties with industries, national research institutes, local governments, etc., with the aim of conducting research and development to realize a Super Smart Society and cultivating the human resources who will lead that society. Furthermore, in conjunction with the WISE Tokyo Tech Academy for Super Smart Society, which was established following the consortium, we have constructed an unprecedented human resource development system. This system includes internships at Consortium Partners for affiliated super doctorate candidates and doctoral dissertation research based on themes of collaborative research with partners. It also features practical lectures on the social implementation of research by lecturers invited from partners.

Of particular note are the Matching Workshops between students and Consortium Partners, which lead to internships for students. These workshops are valuable events that enable students and partners to exchange information about mutual seeds and needs, and also lead to future employment opportunities. The research and education fields serve as advanced experimental facilities in various areas of the Super Smart Society. These fields are not only open to students and faculty members, but also to researchers from Consortium Partners. We expect these fields to become sources of innovation by enabling multiple partners to conduct attempting interdisciplinary research together with students and faculties.

In the last few years, the scope of research has expanded from the initial focus on smart mobility, smart robotics, and quantum science to include smart agriculture and smart ocean. Furthermore, upon the merger of the Tokyo Institute of Technology and Tokyo Medical and Dental University in October 2024, we will include the research fields of smart medicine and healthcare. In this way, we will make further contributions toward the realization of the Super Smart Society for the happiness of all people in the world. We ask you for your continued cooperation in these efforts.

Nobuyuki Iwatsuki
Steering Committee Chair of the Super Smart Society Promotion Consortium

Super Smart Society Promotion Consortium Activity Report (2023 Academic Year)

1. Overview of Activities in the Sixth Year (2023 Academic Year)

1.1. What is the Super Smart Society Promotion Consortium?

The Super Smart Society Promotion Consortium was established in October 2018 with the aim of co-creating a next-generation social collaborative education and research platform that integrates human resource development and research and development through collaboration between industry, government, and academia in order to train leaders who will lead the coming super smart society (Society 5.0). As of April 2024, the 62 partners (not including individual members) shown in Table 1-1 including research institutes, local governments, and private companies are participating in this consortium to promote open innovation and open education for a super smart society.

The Super Smart Society Promotion Consortium has three committees, as shown in Figure 1-1. 1) The Super Smart Society Promotion Committee provides networking opportunities for a super smart society, plans and holds events such as the Super Smart Society Promotion Forum, and provides social enlightenment through One-day Schools. 2) The Social Collaborative Education Steering Committee assists with human resource development and career support. It helps with human resource development in collaboration with the WISE-Super Smart Society (SSS) Program (established at the Tokyo Institute of Technology in April 2020), and supports off-campus projects (internships). 3) The Interdisciplinary Research Promotion Committee helps to coordinate research and development teams, holds Matching Workshops, and helps develop SSS Research and Education fields (R&E fields). The activities during the 2023 academic year are summarized in this report according to each committee.

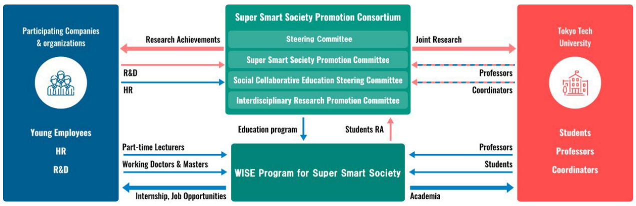


Figure 1-1 Organization of the consortium

Table 1-1 Consortium partners (As of April, 2024)

1	Tokyo Institute of Technology	32	Mitsubishi Jisho Design Inc.
2	Information Technology and Human Factors, National Institute of Advanced Industrial Science and Technology	33	Mizuho–DL Financial Technology Co., Ltd.
		34	NEC Corporation
3	Japan Agency for Marine-Earth Science and Technology	35	Nileworks Inc.
4	National Agriculture and Food Research Organization	36	NIPPON TELEGRAPH AND TELEPHONE CORPORATION
5	National Institutes for Quantum Science and Technology	37	NSK Ltd.
6	National Institute of Information and Communications Technology	38	NTT Urban Solutions, Inc.
7	RIKEN Center for Advanced Intelligence Project	39	ORNIS Corporation
8	ACSL Ltd.	40	Panasonic Corporation
9	AGC Inc.	41	Rakuten Mobile, Inc.
10	aiwell Inc.	42	Ricoh Company, Ltd.
11	ANRITSU CORPORATION	43	ROCKY-ICHIMARU Co., Ltd.
12	Azbil Corporation	44	SHO-BOND CORPORATION
13	Central Japan Railway Company	45	SoftBank Corp.
14	DENSO Corporation	46	Tokyu Research Institute, Inc.
15	FUJIFILM Holdings Corporation	47	TOSHIBA CORPORATION
16	FUJITSU LIMITED	48	Tressbio Laboratory Co., Ltd.
17	Hitachi, Ltd.	49	TsukArm Robotics Inc.
18	Honda Research Institute Japan Co., Ltd.	50	YASKAWA Electric Corporation
19	Idemitsu Kosan Co.,Ltd.	51	Yokogawa Electric Corporation
20	ITD Lab Corporation	52	Ministry of Agriculture, Forestry and Fisheries
21	ITOKI CORPORATION	53	City of Yokohama
22	JTEKT CORPORATION	54	Kawasaki City
23	Kawasaki Heavy Industries, Ltd.	55	Meguro City
24	KDDI CORPORATION	56	Ota City
25	Koden Electronics Co., Ltd.	57	The Ecozzeria Association
26	Komatsu Ltd.	58	Institute for Marine Culture and Research Promotion
27	Kubota Corporation	59	Japan Electronics and Information Technology Industries Association
28	LG Japan Lab Inc.	60	Kanto Head Office, Organization for Small & Medium Enterprises and Regional Innovation, JAPAN
29	Mazda Motor Corporation		
30	MITSUBISHI ESTATE CO., LTD.	61	Marine Open Innovation Institute
31	Mitsubishi Electric Corporation	62	The Ocean Policy Research Institute, The Sasakawa Peace Foundation

1.2. Activity highlights of the sixth year (2023 academic year)

Table 1-2 gives an overview of the activities and events of the Super Smart Society (SSS) Promotion Consortium during the sixth year (2023 academic year), along with a list of corresponding committees. The various committees meet together four times a year in order to plan SSS promotion projects and various events. In the 2023 academic year, restrictions on activities due to the COVID-19 pandemic were lifted once the Japanese government reclassified COVID-19 as a Class 5 infectious disease. This made it possible to once again hold events completely in person. For example, activities at the Matching Workshop held in November were extremely successful and the number of matches was the highest ever. The 2023 academic year marked the fifth anniversary of the establishment of the consortium. In commemoration of this milestone, we held the 5th Anniversary Symposium in March 2024 under the theme "What should we do now for the future human society?" At the symposium, we discussed the role that the consortium should play in securing the future of humanity. Details of each event, including these, are summarized in this activity report.

The consortium has jointly obtained multiple competitive funds, including a grant from the WISE Program (Doctoral Program for World-leading Innovative & Smart Education) operated by Ministry of Education, Culture, Sports, Science and Technology. The purpose of these funds is to promote open innovation and open education pertaining to the Super Smart Society. Thus far, we have constructed the nine SSS R&E fields shown in Table 1-3 on the next page. These R&E fields are positioned as microcosms of the ideal Super Smart Society, and are open platforms that can be used for education and research by any Consortium Partner. Please take advantage of these resources.

Table 1-2 SSS Promotion Consortium activities in AY2023

Month	Events	Committee
Apr., May 2023	Super Smart Society Innovation A4	(2)
May	International round table for blue-economy Suruga-bay	(1)
Jun.	18th Joint Committee	(1), (2), (3)
Jun.	Matching Workshop (Spring,2023)	(3)
Jun., Jul.	Super Smart Society Innovation A3	(2)
Aug., Sep.	Off-campus Project (Summer, 2023)	(2)
Sep.	19th Joint Committee	(1), (2), (3)
Sep.	Super Smart Society Promotion Forum	(1)
Oct.	SSS One-day School	(1)
Oct., Nov.	Super Smart Society Innovation A1, A2	(2)
Oct., Nov.	Ota City Entrepreneurship Seminar	(2)
Nov.	20th Joint Committee	(1), (2), (3)
Nov.	Matching Workshop (Autumn 2023)	(3)
Dec., Jan. 2024	Super Smart Society Innovation A5	(2)
Feb., Mar.	Off-campus Project (Spring 2024)	(2)
Mar.	21th Joint Committee	(1), (2), (3)
Mar.	5th Anniversary Symposium	(1)

(1) The Super Smart Society Promotion Committee
(2) The Social Collaborative Education Steering Committee
(3) The Interdisciplinary Research Promotion Committee

During the first phase of the SSS promotion project from the 2018 to 2023 academic years, the consortium achieved its goal of "building a new education and research platform through industry-government-academia collaboration that integrates everything from human resource development to R&D." In the 2024 academic year, the Tokyo Institute of Technology and Tokyo Medical and Dental University, which are the leading partners of the consortium, will merge to form Science Tokyo (the Institute of Science Tokyo). Accordingly, the consortium will expand its technical scope to include the medical and pharmaceutical fields, including smart healthcare. We plan to transition to the second phase of the SSS promotion project from the 2025 academic year, with the aim of creating new industries through industry-government-academia collaboration. We look forward to combining the technologies and knowledge of Consortium Partners to create a Super Smart Society for a brighter future of human society.

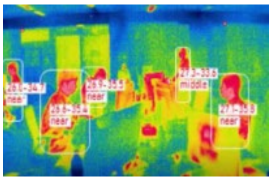
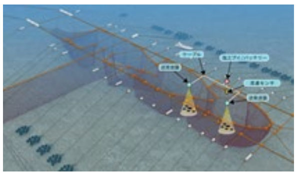
2. Activities of the Super Smart Society Promotion Committee

2.1. SSS Promotion Forum

In the first half of the 2023 academic year, we held the 8th Super Smart Society Promotion Forum. In the second half, in order to commemorate the fifth anniversary of establishing the consortium, we held the Super Smart Society Promotion Consortium 5th Anniversary Symposium instead of the usual forum.

Figure 2-1 The 8th SSS Promotion Forum program

Table 1-3 SSS Research and Education fields

Smart Mobility	Smart Robotics	Quantum Science
 A platform for new smart mobility services by utilizing automated driving vehicles and cutting-edge technologies, such as digital twin, 5G/6G, and millimeter wave V2X.	 A platform for utilizing robots in the fields of land, sky, aqua, and manufacturing. We are conducting research about four-legged robots for outdoor fields (land), drones (sky), underwater robots and drones(aqua), and digital manufacturing technology, etc.	 A platform for quantum computing and quantum sensors for the next generation. We are conducting research and application of ultrafast next-generation quantum computers and ultrasensitive quantum sensors.
Artificial Intelligence	Smart Workplaces	Smart Agriculture
 A platform for artificial Intelligence (AI). The supercomputer "TSUBAME" and Wi-Fi6 are used to build a platform for the use of machine learning services.	 A platform for smart workplaces with the aim of establishing better workplaces. We are building workplaces for the post-COVID-19 era, including air conditioning control using a variety of sensors and AI.	 A platform for smart agriculture in response to problems related to small-scale agriculture in Japan. We are working on remote agricultural technology that enables automated and stable production of high-quality crops by fully utilizing AI, IoT, and robot technology.
Smart Infrastructure Maintenance	Smart Building	Smart Ocean
 A platform for achieving Sustainable Social Infrastructure (SSI), which supports our life and society. Its goal is to ensure secure maintenance of infrastructure and to enhance urban functionality and resilience.	 A platform for evaluating the safety and continuity of use of buildings and providing occupants with early notification of building conditions in the event of earthquakes and typhoons. The platform uses data from high-performance sensors densely installed in buildings.	 A platform for marine digitalization to visualize the flow of information in the ocean and demonstrate optimization techniques over industry boundaries for sustainable ocean use.

5G/6G: The $5^{th}/6^{th}$ Generation mobile communication system,
V2X: Vehicle to Everything(X),
AI: Artificial Intelligence,
IoT: Internet of Things.

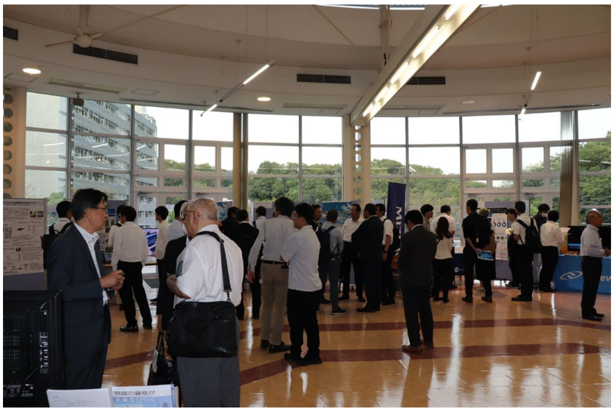


Figure 2-2 Poster exhibition

(1) The 8th Super Smart Society Promotion Forum “Re-Engineering of Agriculture towards Super Smart Society”

Japanese agriculture is now facing such challenges as small and diverse farms, the decline and aging of farmers, and the difficulty of predicting productivity and profitability. To solve these challenges and also to continuously develop Japanese agriculture, it is essential to evolve to super smart agriculture by using cutting-edge technologies such as IoT, AI, and robotics to accelerate digital transformation of the entire agricultural management as a total system. Another essential measure is the implementation of super smart technology which for total integration of production, processing, distribution, and consumption.

To facilitate this transition, we held a Super Smart Society Promotion Forum under the theme of “Re-Engineering of Agriculture towards Super Smart Society.” The forum introduced innovative technology and cutting-edge knowledge for forecasting productivity and profitability, and for supporting sustainable agriculture (Figure 2-1). The forum also featured poster exhibitions by five agriculture-related organizations and Tokyo Institute of Technology (Figure 2-2), a tour of the smart agriculture R&E field (Figure 2-3), and a panel discussion (Figure 2-4).

The forum was organized by the Super Smart Society Promotion Consortium and co-hosted by Tokyo Institute of Technology, the Tokyo Tech Academy for Super Smart Society, and the National Agriculture and Food Research Organization. In addition to sponsors such as the Institute of Electronics, Information and Communication Engineers (IEICE), Information Processing Society of Japan (IPSJ), and the Institute of Electrical and Electronics Engineers (IEEE) Japan Council, the forum was also sponsored by agriculture-related organizations such as the Japanese Society of Agricultural Machinery and Food Engineers (formerly The Japanese Society of Agricultural Machinery), the Society of Agricultural Structures Japan, the Japanese Society of Farm Work Research, the Japanese Society of Agricultural Informatics, the Society of Agricultural Meteorology of Japan, the Japan Association of International Commission of Agricultural and Biosystems Engineering, the Japan Greenhouse Horticulture Association, and the Hot Agriculture Group (Japan Agricultural Corporation Association), as well as Keisen University, which collaborates with the consortium in organic agriculture. The forum also received support from the Japan Society for Bioscience, Biotechnology, and Agrochemistry, Ota City, Meguro City, Kawasaki City, Yokohama City Economic Affairs Bureau, Sasakawa Peace Foundation, and Tokyo Tech Alumni Association.

Figure 2-3 Tour of the Smart Agriculture Research and Education field

At the forum, opening remarks were given by Professor Kotaro Inoue, Dean of the School of Engineering. Next, a greeting was given by the guest of honor, Mr. Shin Sato, Minister’s Secretariat Councillor at the Ministry of Agriculture, Forestry and Fisheries. Next, Mr. Masakazu Yamada, President of Agribusiness General Planning Division at the National Federation of Agricultural Co-operative Associations (Zen-Noh), delivered a keynote speech entitled “Changes in the environment surrounding agriculture and the association’s smart agriculture initiatives.” The keynote speech explained how Zen-Noh is working on maintaining and expanding the production base as one of the pillars of measures to respond to the recent environmental changes surrounding agriculture. In particular, in the area of smart agriculture, Zen-Noh is using map information as a starting point to improve the environment and disseminate it with the aim of making cultivation management smarter.

Afterwards, Dr. Tetsuo Maoka, Executive Director of The National Agriculture and Food Research Organization, gave a lecture entitled “Integrated promotion of strategy for sustainable food systems (MIDORI) and smart agriculture in NARO.” Dr. Satoshi Iida, Senior Technical Advisor of Kubota Corporation, delivered a lecture under the theme of “Kubota’s Smart Agriculture and Future Directions.” Associate Professor Hideharu Takahashi, School of Engineering at the Tokyo Institute of Technology, gave a lecture entitled “Challenge for ‘Super’ Smart Agriculture Based on Seeds of Engineering Wisdom.” In particular, Dr. Iida introduced the development status and future outlook for smart agriculture technologies, including data-driven precision agriculture using the Kubota Smart Agri System (KSAS) and ultra-labor-saving automation and unmanned farming, which are being developed to solve the declining farming population and other issues facing Japanese agriculture.

Afterwards, a poster exhibition was held with participation from the following:

(1) National Agriculture and Food Research Organization (NARO)
(2) Kubota Corporation
(3) Nileworks Inc.
(4) Mizuho-DL Financial Technology Co., Ltd.
(5) Tressbio Laboratory Co., Ltd.
(6) Takahashi Lab (School of Engineering)
(7) Yamamura Lab (School of Computing)
(8) Masuda Lab (School of Life Science and Technology)
(9) Tokyo Tech Academy for Super Smart Society (WISE-SSS) (Smart Agriculture Research Field)
(10) Super Smart Society Promotion Consortium

Figure 2-4 Panel discussion of Smart Agriculture

Finally, a panel discussion was held, with Professor Masayuki Yamamura (School of Computing, Tokyo Institute of Technology) serving as facilitator. The four panelists participating in the discussion consisted of the three lecturers introduced above and Mr. Tadashi Kawamoto of Tressbio Laboratory Co., Ltd. The lively panel discussion addressed the challenges and visions for new agriculture, as well as what agriculture should look like in the future social system.

The forum was held in person and simultaneously streamed online. A total of about 291 people participated from both inside and outside of Tokyo Tech, including 124 people in Suzukake Hall and 167 people online.

(2) Super Smart Society Promotion Consortium 5th Anniversary Symposium

The Super Smart Society Promotion Consortium was established in 2018 and recently celebrated its fifth anniversary. In commemoration of this milestone, we held the Super Smart Society Promotion Consortium 5th Anniversary Symposium on March 13, 2024. The overall theme of the symposium was "What should we do now for the future human society?" The symposium featured six lectures by key speakers, starting with President Kazuya Masu. The speakers introduced cutting-edge knowledge from a broad perspective on fields such as DX (Digital Transformation), ICT (Information and Communication Technology), AI, agriculture, medical care, human resource development, future predictions, and SDGs (Sustainable Development Goals). There was also a video message from President Thomas M. Coughlin of IEEE. Another feature of the symposium was a poster exhibition held on the eight R&E fields being pursued by the Tokyo Tech Academy for Super Smart Society.

This forum was hosted by the Super Smart Society Promotion Consortium, co-hosted by Tokyo Tech, Tokyo Medical and Dental University, and the Tokyo Tech Academy for Super Smart Society, and supported by the IEICE, IPSJ, the Japan Society of Mechanical Engineers, SICE, the Japanese Society of Agricultural Informatics, the Japan Society of Applied Physics, the Physical Society of Japan, the Architectural Institute of Japan, the Japan Society for Educational Technology, the Nippon Finance Association, MIRAI SOUZOU, the IEEE Japan Council, and the Japan Science and Technology Agency. The forum was endorsed by the Nikkan Kogyo Shimbun, Ltd., Ota City, Kawasaki City, Meguro City, Yokohama City Economic Affairs Bureau, and the Tokyo Tech Alumni Association. The program is shown in Figure 2-5. In particular, in light of the upcoming launch of Science Tokyo later this year, Tokyo Medical and Dental University joined this year's forum

Figure 2-5 The SSS Promotion Consortium 5th Anniversary Symposium program

has a co-host.

Professor Hiroichi Yanase of the Institute for Liberal Arts served as the moderator. Opening remarks were given by Professor Kei Sakaguchi, Coordinator of the Super Smart Society Promotion Consortium. Next, greetings were given by guest of honor, Mr. Hiroki Matsuo, Secretary General for Science, Technology and Innovation Policy at the Cabinet Office. Seven distinguished speakers then delivered speeches during the first and second sessions of the symposium (Figure 2-6). The overview of each lecture is as follows:

[Lecture 1] Embrace the Future Now

Dr. Kazuya Masu (President, Tokyo Institute of Technology)

Figure 2-6 Group photo at the 5th Anniversary Symposium

We often encounter challenges where we are unsure how to tackle them. At such times, we are tempted to postpone discussions and decisions. Procrastinating behavior produces nothing. Tokyo Tech has decided not to defer these discussions and decisions when considering what kind of university we want to be at the beginning of the Reiwa Period, and we are keenly aware of the importance of diversity and tolerance. Specifically, taking into consideration the high ratio of women at science and engineering universities outside of Japan, Tokyo Tech will establish quotas for women among faculty and students, and will work to systematically increase the ratio of women at Tokyo Tech.

[Lecture 2] Social Systems Supporting “Fun-Will-Effort”

Dr. Nobuhiro Endo (Executive Advisor, NEC Corporation)

The Earth is finite, and therefore the production of energy and food is also finite. As the human population approaches 10 billion, the establishment of a smart society that is holistically optimal and sustainable is urgently required. Human beings are the main actors in the creation of value in human society. It is essential to establish social systems that respects individual initiative and supports the diversity of people based on “Fun” (finding enjoyment) “Will” (thirst for knowledge) and “Effort” (contribution to society).

[Lecture 3] Super Smart Society for the Future of Humanity: Challenges in the Agri-Food Industry

Dr. Kazuo Kyuma (President, National Agriculture and Food Research Organization)

This presentation outlined NARO’s efforts to solve issues related to the agriculture and food industries and to realize Society 5.0 in the field of agriculture, while at the same time considering environmental changes such as food issues, climate change, and geopolitical risks, as well as the current state of land subsidence in Japan. Specific efforts include the development of innovative soybean varieties, smart agriculture demonstration experiments, remote agricultural support systems, CO_2 zero-emission agriculture, and AI matching of supply and demand.

[Lecture 4] Integration of Medicine and Healthcare for a Super Smart Society

Dr. Koji Fujita (Deputy Director and Professor at Open Innovation Center, Tokyo Medical and Dental University)

With the transition to a Super Smart Society, medical care is extending beyond the confines of hospitals. This discussion focused on the importance of detecting signs of illness and preventing disease as medical care becomes an integral part of our daily lives, seamlessly merging with healthcare. Dr. Fujita also introduced new medical and engineering collaboration initiatives.

[Lecture 5] NTT as a Creator of New Value and Accelerator of a Global Sustainable Society

Dr. Katsuhiko Kawazoe (Senior Executive Vice President, Nippon Telegraph and Telephone Corporation)

The surge in data volume is leading to an escalating power consumption, pushing ICT’s sustainability into jeopardy. At NTT, our objective is to ensure sustainability through our advocacy and promotion of IOWN (Innovative Optical and Wireless Network), focusing on highly energy-efficient optical technology rather than electricity. This lecture delved into NTT’s initiatives with IOWN. IOWN has the advantages of low power consumption, large capacity, high quality, and low latency. Examples of using IOWN include music sessions connecting remote locations and remote surgery.

[Lecture 6] “AI for Science” in Japan: Innovative Evolution of Science Based on Basic Models

Professor Satoshi Matsuoka (Director, RIKEN Center for Computational Science)

AGIS (Artificial General Intelligence for Science) is working to advance science and technology based on the development of the supercomputers Fugaku and Tsubame. AI has passed through the processes of recognition, imitation, and generation, and is now approaching the realm of automated scientific discovery. AI will now be able to generate programs, hypotheses, and experimental simulations, and we are entering an era in which AI will rapidly accelerate science. Specifically, generative AI is being applied to solar cell materials, car design, drug discovery, and other fields, and there is a vision for how these applications will contribute to the revolutionary evolution of science.

[Lecture 7] Past and Future

Professor Takeshi Nakajima (Professor, the Institute for Liberal Arts, Tokyo Institute of Technology)

Modern academic knowledge is made up of subdivided specializations. This results in only partial optimization, and we lose sight of the interconnectedness, organicity, and comprehensiveness of knowledge, and our vision of future society becomes narrow-minded. To address this problem, by reconsidering old ways of knowing, we hope to gain a perspective that can see into the future. Furthermore, in regard to how we deal with death and deceased individuals, the importance of evocation is emphasized, rather than the revival of the deceased through digital IT technology.

[Video Message]
IEEE and the Future of Humanity

Dr. Thomas M. Coughlin (IEEE President)

Following the congratulatory address on the fifth anniversary of the founding of the Super Smart Society Promotion Consortium, Dr. Coughlin introduced the purpose, organization, responsibilities, and activities of IEEE, which is the world’s largest academic research organization in the fields of electrical and information engineering. He emphasized that IEEE is concerned not only with technological innovation, but also with formulating international standards and contributing to the international community.

Using the time between the first session and the second, we held a poster exhibition on the R&E fields being promoted by the Super Smart Society Promotion Consortium (Figure 2-7).

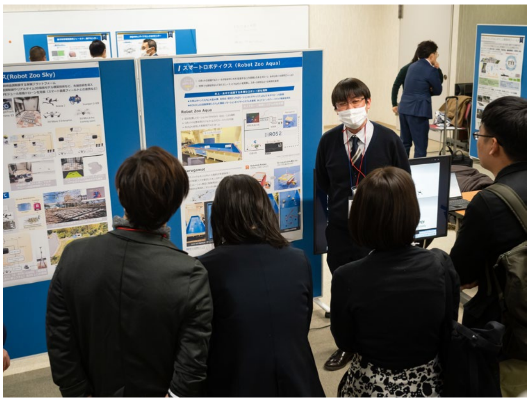


Figure 2-7 Poster presentation of Research and Education fields

We set up eleven booths, one for each field, and each booth gave a presentation. Some booths also demonstrated equipment for the smart workplace, robotics LAND, and smart agriculture.

The event was held in person and streamed online at the same time. 136 people attended in person and 204 people attended online, for a total of 340 people. In closing, we would like to express our gratitude to all those who agreed to give presentations, including Consortium Partners of the Super Smart Society Promotion Consortium.

2.2. One-day School

As part of recurrent education for working adults, we, alike previous years, provided opportunities for practical experience in R&E fields for Consortium Partners in the Super Smart Society Promotion Consortium (Figure 2-8). There were four fields in the 2022 academic year. In the 2023 academic year, we added smart robotics (LAND) and smart agriculture to bring the total number of fields to six (smart robotics, quantum science, smart agriculture, artificial intelligence, smart mobility, and smart workplace). Table 2-1 shows the status of implementation.

In principle, the maximum number of participants is limited to 10 per field. This ensures close discussions with the faculty members in charge, and opportunities for all participants to come into direct contact with the R&E fields. The One-day School for the smart agriculture R&E field was conducted at the Suzukakedai Campus, for the workplace R&E field at Otemachi 3x3 Lab Future, and for other fields at the Ookayama Campus. 40 people from 11 companies participated in the event. Through hands-on exercises and lively discussions, they made technical contributions to Consortium Partners. Compared to the 2022 academic year, the number of Consortium Partners and people has more than doubled. In the future, we plan to expand the number of fields and their technical disciplines so that participating partners can further utilize these R&E fields.

Table 2-1 One-day School program

Education and Research Fields	Date	Contents of Programs (lecture/exercises)
Smart Robotics (LAND)	Sep. 29th	· Lecture on fundamentals of robotics · Introduction of facilities · Programming exercise using cooperative robots
Quantum Science	Oct. 5th	· Cooling down qubit devices and observation of quantum phenomena · Hands-on learning of techniques required for precise measurements · Practice concerning the fabrication of superconducting thin films that constitute quantum sensors and characterization of their physical properties
Smart Agriculture	Oct. 10th	· Lecture on Ecosystems and Genomics · Aerial photography by drone 10 and hands-on training with agricultural robots
Artificial Intelligence	Oct. 16th	· Lecture on Neural Network · Exercise using Google Colab · Introduction of TSUBAME
Smart Mobility	Oct. 19th	· Lectures on autonomous driving, ITS, and next-generation wireless communication technology · Exercises using autonomous-driving vehicle
Smart Workplace	Oct. 27th	· Introduction of Smart workplace education and research field · Technologies and sensors in the smart workplace field · Visualization of human thermal comfort and droplet nuclei behaviors

Figure 2-8 One-day School for Smart Agriculture Research and Education field

3. Activities of the Social Collaborative Education Steering Committee

3.1. Implementation of cyber/physical Off-campus Projects

As part of the activities of the Social Collaborative Education Steering Committee, this consortium together with the Tokyo Tech Academy for Super Smart Society are planning cyber/physical Off-campus Projects (interdisciplinary internships for master’s degree program and doctoral degree program students). In the 2023 academic year, we asked the Consortium Partners to recruit internships.

Internships for master’s degree programs are a major requirement for enrollment in the WISE-SSS Program, and internships for doctoral degree programs are a major requirement for completion of the WISE-SSS Program, so highly motivated students can be expected to apply.

For internships for master’s degree programs, we posted information on the consortium’s website about the openings at each Consortium Partner and made it widely known to students. The Japanese government classified COVID-19 as a Class 5 disease in May 2023, so on-site internships began in earnest. We were able to accept three students for internships at four Consortium Partners for the summer of 2023. For the winter of 2023, six partners have accepted four students for internships. The impact of COVID-19 was serious at this time and major

Table 3-1 Courses on Super Smart Society Innovation

Courses		Number of registered students (AY2023)	Starting academic year
A1	Frontiers in Quantum Technology	28	2020
A2	IoT/Robotics/Smart city	67	2020
A3	Frontiers in Smart Agriculture	53	2021
A4	Frontiers in Smart Workplace	41	2022
A5	Production Process Innovation	26	2023
Total		215	

issues remained; for example, it was particularly difficult to set up internships in English for international students.

Internships for master's degree programs in the 2024 academic year are envisioned for the summer break (August 2024) and the spring break of 2024. We look forward to your continued cooperation, including with regards to internships in English.

For internships for doctoral students starting in the 2022 academic year, while protecting the privacy of students, we built a framework for sharing information summarizing the research themes and research achievements of each student with Consortium Partners. This enables reforms to ensure efficient matching with partners.

In the 2024 academic year, we hope to continue the active discovery of new fields where the needs of participating partners can be matched with the professional abilities of students, and that more internships can be accepted.

Also, because of the spread of globalization, we want to promote internships in English and plan overseas internships. We look forward to continued cooperation from Consortium Partners.

3.2. Courses related to Super Smart Society Innovation

The Tokyo Tech Academy for Super Smart Society offers courses related to Super Smart Society Innovation to students enrolled in the Academy, as well as to interested master's and doctoral students. In order to cultivate the expertise and comprehensive viewpoint needed to realize a Super Smart Society, the consortium is working with Consortium Partners to provide an omnibus of lectures on cutting-edge real-world issues. This allows us to create original science and technologies in specialized fields spanning both cyber and physical fields, and resolve various social issues by having an overview of the path from quantum science to a super smart society, with the aim of developing students with leadership skills capable of leading each sector of industry, government, and academia.

In the 2023 academic year, with the cooperation of Consortium Partners, we started social cooperation courses related to Super Smart Society Innovation shown in Table 3-1.

We asked researchers from Consortium Partners to create an omnibus of lecture videos covering various cutting-edge topics. We then distributed these videos on demand so that a diverse range of students could study at their own pace. Students were also able to use the bulletin board system to hold discussions.

The on-demand video-style lectures and discussions using a bulletin board system were extremely well-received by students in a variety of different systems and courses at Tokyo Tech. We received an enormous amount of positive feedback on the contents and format of the lectures.

Going forward, we plan to add one additional course each year. In response to the ever-evolving nature of technology, we have decided to suspend each course after four years and re-examine the course, including the theme of the course (lecture videos have been reused with minor modifications).

In the 2023 academic year, we added "A5: Production Process Innovation." In the 2024 academic year, we plan to suspend "A1: Frontier in Quantum Technology" and "A2: IoT/Robotics/Smart City" so that we can reconsider the courses and their themes.

We look forward to continued cooperation from Consortium Partners.

3.3. Ota City Start-up Experience Off-campus Project

From the 2021 academic year, the Ota City Start-up Experience Off-campus Project is being executed in collaboration with the Industrial Promotion Section, Department of Industry and Economy, Ota City. In the 2021 academic year, the project was executed in the form of a two-day seminar, but in the 2022 academic year, it was formally offered as a seven-day course with three part-time lecturers. However, because the project is centered on mentoring business plans for students with start-up themes, only three students took the course, despite the fact that a wide variety of mentors were available and students also visited various facilities.

Therefore, in the 2023 academic year, we offered two types of courses: the Ota City Start-Up Practice Off-campus Project for doctoral students, which is a course centered on mentoring for business plans, and the Ota City Start-up Experience Off-campus Project for master's students, which is a course that involves group work to learn about the start-up mindset (Figure 3-1).

The Ota City Start-up Experience Off-campus Project for master's students will invite guests such as CEOs of ventures starting from Tokyo Tech to speak about their business experiences and allow students to engage in practical exercises related to starting their own companies, with the aim of teaching students about the option of starting a company as a career path. The Ota City Start-Up Practice Off-campus Project for doctoral students will provide a practical curriculum aimed at commercializing research themes through the creation of specific business plans for students interested in starting up ventures.

As part of the common curriculum of "practice" and "experience," students received stimulating experiences such as lectures on business experiences by guests such as CEOs of ventures started from Tokyo Tech, fieldwork unique to the Ota City collaboration project, and tours of unique facilities in the city that are normally difficult to access. Examples of facilities include tours of cutting-edge incubation facilities and local factories, and explanations of business by facility representatives (Haneda Innovation City (HIC), JAL Sky Museum, factory apartments (Techno FRONT Morigasaki), etc.).

Figure 3-1 Ota City Start-up Experience Off-campus Project

Three students (one doctoral student, one master's student, and one bachelor's student) registered for the practical project for doctoral students, and 31 students registered for the experience project for master's students. Both projects were well received by students.

3.4. Tours of Consortium Partners

Starting from the 2023 academic year, we will be holding tours of Consortium Partners for students. This event will provide an opportunity for students (mainly master's students who are enrolled or wish to enroll at the Tokyo Tech Academy for Super Smart Society) to visit actual work sites and engage in technical discussions with people working at Consortium Partners. The purpose of the event is to create an opportunity for networking between Consortium Partners and students, and to further explore the possibility of collaborative research and internships.

In the 2023 academic year, the following four Consortium Partners hosted tours (Table 3-2, in order of implementation date).

Table 3-2 Tours of Consortium Partners

	Consortium Partner	Number of participants
1	National Institutes for Quantum Science and Technology (QST)	7
2	DENSO Corporation	8
3	Mitsubishi Jisho Design Inc. and The Ecozzeria Association	6
4	Yokogawa Electric Corporation	6

The tours were well received by students, and we have received numerous inquiries from Consortium Partners about tours in 2024. We look forward to continued cooperation from Consortium Partners.

4. Activities of the Interdisciplinary Research Promotion Committee

4.1. Matching Workshops

In conjunction with the lifting of COVID-19 restrictions in the 2023 academic year, we were able to resume Matching Workshops held in a completely in-person format. We held interdisciplinary Matching Workshops on June 7 in the spring

Figure 4-1 Matching Workshop (Autumn, 2023)

semesters and on November 29 in the fall semester. These workshops combined the Seeds Round (S-Round) and Needs-Round (N-Round). Each workshop began with an S-Round where Tokyo Tech students presented their ideas. This was followed by an N-Round in which Consortium Partners in the Super Smart Society Promotion Consortium presented their needs. At the end of the workshop, a networking event was held to promote exchange among participants (Figure 4-1). The number of matches compared to last year increased, which is likely due to the effect of holding the workshops in person. Specifically, in the spring semester, 42 students and researchers from 21 Consortium Partners participated, and 21 matches were made with 9 Partners. In the fall semester, 41 students and researchers from 21 Consortium Partners participated, and 24 matches were made with 8 Partners.

4.2. SSS Research and Education fields

4.2.1. Smart Mobility

We are building a platform to educate students enrolled in the WISE-SSS Program, and conduct collaborative research on

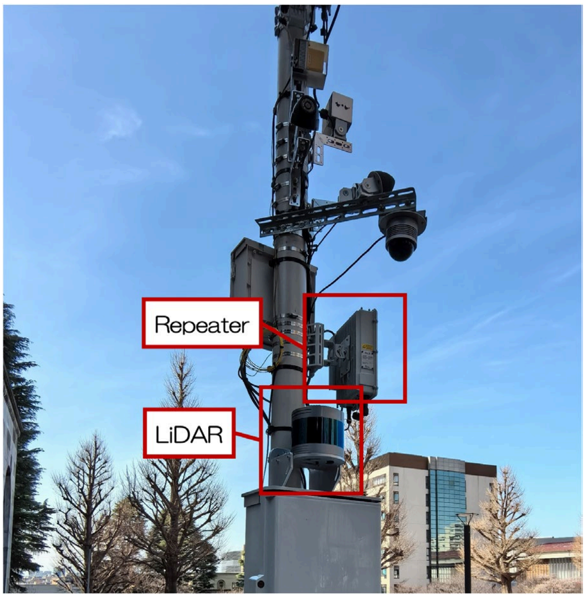
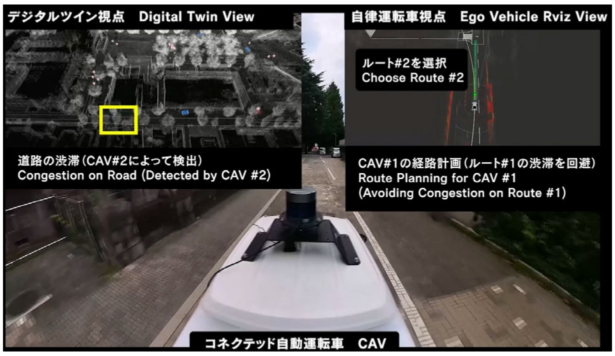


Figure 4-2 Roadside unit

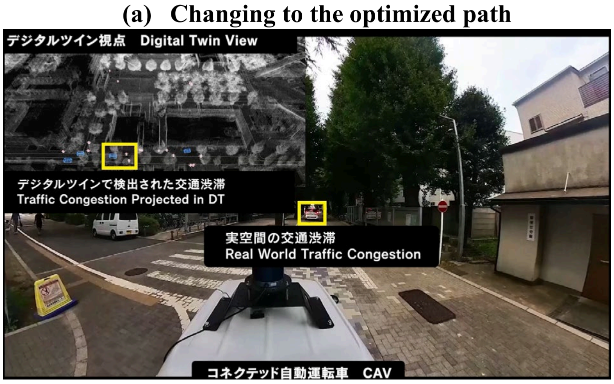
automated driving and mobility services with Consortium Partners of the Super Smart Society Promotion Consortium.

In the 2023 academic year, we further enhanced the functionality of the Smart Mobility Digital Twin (SMDT) platform, which we had built in 2022 to reproduce real-world traffic conditions in cyberspace. For example, we developed the Internet of Federated Digital Twin (IoFDT) platform to rapidly deploy Digital Twin (DT) applications. Additionally, as shown in Figure 4-2, we have permanently installed devices such as LiDAR (Light Detection and Ranging) and 5G repeaters on roadside units, thereby creating a system for continuous operation.

When evaluating the SMDT platform, we examined not only at single KPIs (Key Performance Indicators) such as latency and throughput, but also the usefulness of smart mobility-related applications and services developed on the SMDT platform. For example, we used SMDT to develop an optimal route planning system for autonomous vehicles. As shown in Figure 4-3, autonomous vehicles are equipped with sensors such as LiDAR and cameras. However, the detection range of theses sensors is limited and they cannot ascertain in real-time the traffic conditions outside the detection range. To solve this, SMDT, which possesses real-time and global traffic information, will analyze the traffic situation in real time. It then uses that analysis as a basis for transmitting the optimal route to the autonomous vehicle. This enables the vehicle to smoothly navigate to the new route and reach its destination efficiently. We also developed a potential traffic collision prediction system using SMDT, as shown in Figure 4-4. Using real-time traffic information within SMDT, the system predicts the routes of traffic participants such as vehicles and pedestrians. If a collision is predicted, it notifies drivers of danger warnings and recommended actions such as deceleration, while also using 5G to transmit warning information to pedestrians to avoid collisions.



(a) Changing to the optimized path



(b) Congestion in physical space and congestion detected in DT

Figure 4-3 Optimized path planning for autonomous driving by SMDT

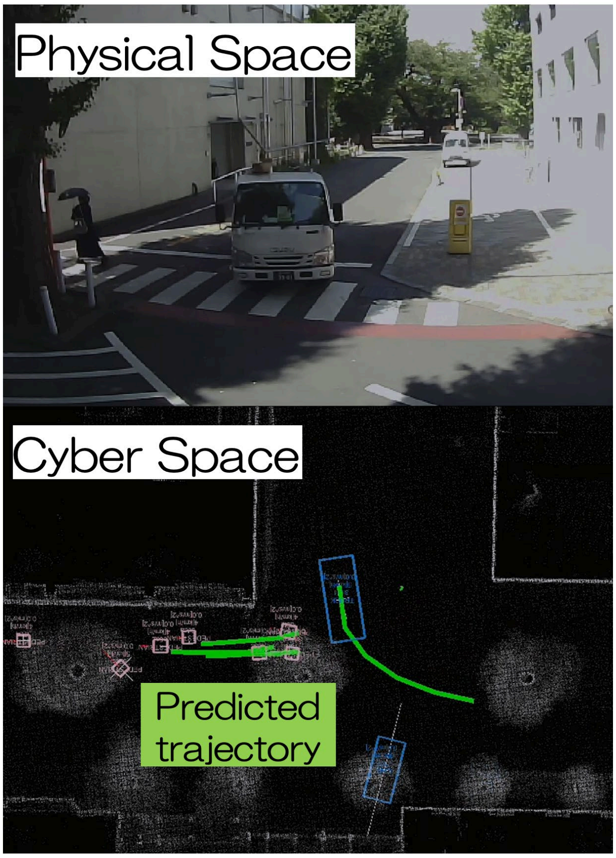


Figure 4-4 Trajectory and collision prediction by SMDT

These environments are open to use by Consortium Partners and students enrolled in the Tokyo Tech Academy for Super Smart Society. We expect to create a platform for the creation of new services through the fusion of different fields and joint research. Through events such as the One-day School for Consortium Partners and exercises and tours for students enrolled in the WISE Program, we utilized the R&E field of smart mobility to conduct exercises and demonstrations aimed at learning and experiencing the basic technologies that will realize autonomous driving.

4.2.2. Smart Robotics

- **Robot Zoo Sky**

During the 2019 academic year, we built Robot Zoo Sky as a platform to simultaneously control heterogeneous drones and mobile robots. The main purpose of this R&E field is to develop efficient and robust environmental monitoring technologies that contribute to supporting damage assessment after a natural disaster, and to contribute to the realization of a super smart society in the context of enhancing societal resilience. Also, through exercises in this R&E field, students will be able to gain the skills to safely control and operate multiple systems connected via a network.

In the 2023 academic year, we intensified our collaboration with the smart agricultural R&E field. Last year, we purchased a Mavic 3Ed drone (DJI Corporation)(Note 1) and completed the construction of an automatic control system for the drone. We also successfully linked an RTK (Real Time Kinematic) module, which enables high-precision position measurement outdoors,

Figure 4-5 Environmental monitoring control on Smart Agriculture Research and Education field

on the ROS2 (Robot Operating System 2). Using this system, we successfully implemented environmental monitoring control in the field (Figure 4-5).

For the field alone, we built a new system that integrates on ROS2 environmental monitoring control and NeuralRecon(Note 2), which enables real-time construction of 3D models based on drone image measurement data. We also proposed a new environmental monitoring control method that feeds back real-time 3D model information, and successfully implemented a prototype. We expect research to expand in the future by further considering algorithms; for example, integrating images from multiple drones. By collaborating with other Consortium Partners, we proposed a new method of human-drone fleet cooperative control in which real-time 3D model information is fed back to humans so that humans can select the filming position and angle. Furthermore, in addition to conventional drone position control, we have proposed a new environmental monitoring control method that includes camera attitude control (Figure 4-6).

(Note 1) Mavic 3E: A quadcopter unmanned aerial vehicle (drone) made by DJI. 3E is the model name.
(Note 2) NeuralRecon: Software that can reconstruct 3D scenes in real time from monocular video signals.

Furthermore, based on the acquired image data, we performed 3D model restoration called Structure-from-Motion. We confirmed that camera attitude control significantly contributed to the accuracy of the model (Figure 4-7). Research and development is progressing smoothly; for example, we submitted these results as an academic paper to an international journal.

We also worked to promote our field by holding demonstration experiments at an exchange event with the IAT (Information and Automation Systems for Process and Material Technology) Team from RWTH Aachen University and at

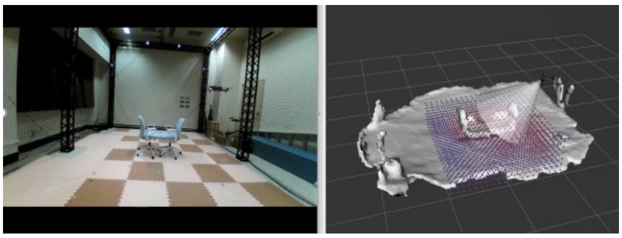


Figure 4-6 Environmental monitoring control with real-time 3D model feedback

Figure 4-7 Reconstructed 3D model (left: without camera control, right: with camera control)

awareness-raising educational events for undergraduate students. Moreover, a paper which we submitted in the last academic year on a method for controlling human-drone fleet cooperative control using virtual reality (VR) technology was accepted and published in the IEEE Open Journal of Control Systems.

- **Robot Zoo Aqua**

Robot Zoo Aqua aims to significantly expand the active field of robots to water. Two years ago, we established this R&E field in the experimental room for the Systems and Control Engineering Department, School of Engineering in Room B107 at West Building 8 on the Ookayama Campus, Tokyo Tech.

This academic year, we succeeded in achieving automatic trajectory tracking control based on a method called Line-of-Sight. This control method uses the automatic control system of the Karugamot water drone that we developed last academic year (Figure 4-8).

We also created a total of three similar water drones, constructed an experimental platform for cooperative control of multiple water drones, and successfully held a cooperative control experiment in which the drones flew in a circular orbit (Figure 4-9).

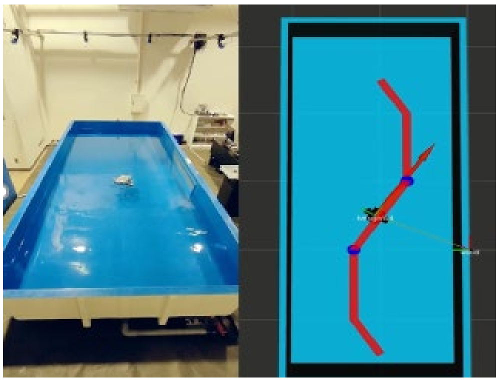


Figure 4-8 Autonomous path tracking control for Unmanned Surface Vehicle (USV)

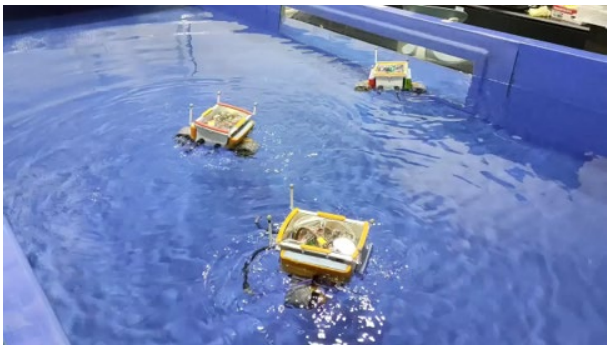


Figure 4-9 Cooperative control systems with multiple USVs

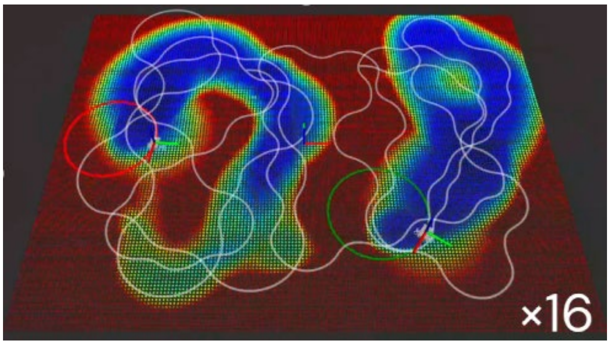


Figure 4-10 Cooperative aquatic environmental monitoring control

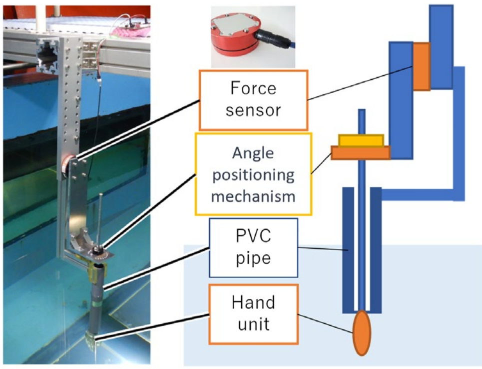


Figure 4-11 Experiment in a circulating water tank for the hand part of the new underwater humanoid robot

Furthermore, we proposed a new method for cooperative monitoring control in an aquatic environment using multiple surface drones, and have successfully submitted the results as a paper at an international conference (Figure 4-10).

For the hand of the new underwater humanoid robot which we developed last academic year, in addition to testing in the still water tank at our field facility, we conducted detailed measurement of the drag and lift characteristics acting on the hand by using the circulating water tank at the University of Tsukuba, which is our collaborative research partner. Eight pressure sensors are embedded in the back and palm of the hand to estimate the fluid force acting on the entire hand from the pressure values. Through tests in the circulating water tank, we confirmed that it is capable of adequately estimating fluid forces acting on the hand (Figure 4-11).

- **Robot Zoo Land**

Robot Zoo Land consists of a group of robot platforms for education and research including collaborative robots, quadruped outdoor field robots developed by Tokyo Tech, and multifunctional robot actuator modules, as well as a group of robot evaluation and control equipment including digital signal processors and controller devices, high-speed motion capture systems for control, and high precision GNSS + INS (Global Navigation Satellite System + Inertial Navigation System) hybrid equipment. By utilizing these facilities, we aim to provide an education and research environment and educational program for smart robotics that utilizes 5G, IoT, and AI. We also seek to promote practical education and research that addresses social issues such as disaster response, infrastructure development, and aging.

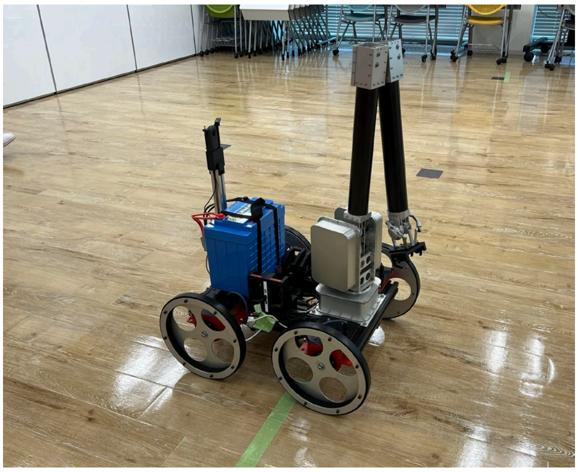


Figure 4-12 Mobile manipulator RhinoUS-II

In the 2023 academic year, in collaboration with Rakuten Mobile, Inc., a Consortium Partner of the Super Smart Society Promotion Consortium, we conducted remote control experiments of mobile manipulators using a dedicated 5G network for experiments. The robot system RhinoUS-II used in the experiment consists of a four-wheel drive robot and a five-degrees-of-freedom light-duty manipulator driven by wires using synthetic fiber ropes (Figure 4-12). Two tablet computers are installed on the main body. One tablet is the control system for operating the wheeled robot, and the other is the control system for operating the manipulator. Movement is controlled by sending operation commands for the vehicle and manipulator to the control PCs via a smartphone application. The operation is monitored by a 360-degree camera installed at the rear. We conducted the experiment in the meeting room at Rakuten Mobile's headquarters.

As a result of the experiment, we confirmed that the robot's movement can be controlled from a smartphone, and that obstacle avoidance operations can be performed remotely using images from a 360-degree camera without having to look directly at the robot itself. Next, we compared the communication speed with the robot using regular 4G and 5G for experiments (downlink speeds more than 10 times faster than 4G). However, there was no significant difference in the feel of operating the robot. Rather, it was apparent that the dominant factors in remote control were the quality of the

Figure 4-13 Teleoperation experiment from a smartphone

transferred video and the superiority/inferiority of the operation interface on the small screen of a smartphone (Figure 4-13).

- **Robot Zoo Manufacturing**

While we held several tours in the 2023 academic year, in terms of research, we have begun attempts to apply this technology to plastic processing. This is in addition to research on smart production technologies based on cutting processing, which was originally envisioned when this field was launched. In recent years, there have been proposals to achieve higher time efficiency and material efficiency by performing additional post-processing using AM (Additive Manufacturing) technologies such as DED (Direct Energy Deposition) and WAAM (Wire Arc Additive Manufacturing) on parts produced with conventional manufacturing technologies. Our attempts in this field in the 2023 academic year are aimed at achieving high added value by improving the surface quality and surface properties through plastic processing as a final finishing step (Figure 4-14). In the coming academic year, we plan to continue examining themes that will lead to smart manufacturing utilizing field resources.

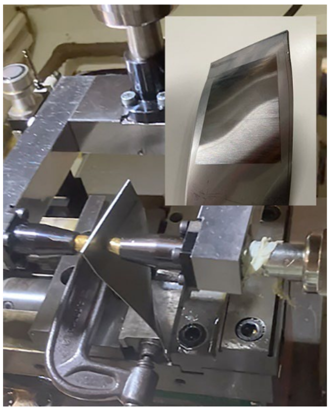


Figure 4-14 Surface modification by plastic forming of free-form surface

4.2.3. Quantum Science

- **Quantum Computing**

Quantum computers are expected to be put into practical use as ultra high-speed next-generation computers that are based on the principles of quantum mechanics. While a normal computer uses a state (bit) of either “0” or “1” for information processing,

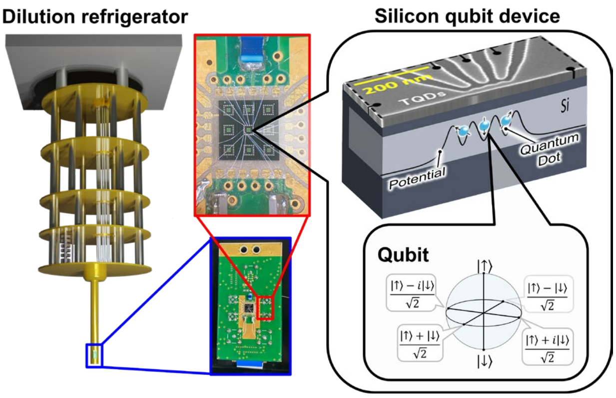


Figure 4-15 Semiconductor qubit measurement system

Figure 4-16 One-day School on Quantum Computing

Figure 4-17 Ishikawadai branch of the SSS Quantum Computing Research and Education field

a quantum computer performs calculations by using a qubit that can take on a superposed state of both 0 and 1. Researchers hope to perform calculations which cannot be handled with conventional computers by integrating qubits on a large scale, operating those qubits, and conducting research on how to apply this technology. Such technology is also expected to contribute to solving the information processing problems required in a super smart society.

Research aimed at realizing qubits is being actively conducted in various physical systems. Although methods using superconductors are advancing, the spin in semiconductor silicon quantum dots is also viewed as a promising system. This method will enable the integration of devices in the future via semiconductor processing technology. It also has the advantage of a long coherence time corresponding to the information retention time.

In this R&E field, while working primarily on this silicon-based method, we are cultivating human resources and conducting education and research for high-level quantum technology. In the 2023 academic year, through collaborative research with Consortium Partners of the Super Smart Society Promotion Consortium, we used the qubit implementation and evaluation system shown in the schematic diagram in Figure 4-15 to achieve coherent spin manipulation in silicon qubit devices and relaxation measurements of spin quantum states. We also evaluated qubit error correlation, which is related to the future performance of silicon quantum computers (Tokyo Tech News, October 11, 2023), and demonstrated a new method of cryogenic electrical wiring suitable for future integration as a peripheral technology for quantum bit devices. Furthermore, we utilized this field to hold events such as the One-day School for Consortium Partners and exercises for students enrolled in the WISE Program. We also held exercises, demonstrations, etc., for high-frequency technology, precision measurement technology, ultra-low temperature technology, vacuum technology, and other technology used in cutting-edge quantum science research (Figure 4-16). We are striving to expand the facility by establishing a new R&E field with a silicon qubit measurement system in the Ishikawadai area (Figure 4-17). We hope that related companies and national research institutes will utilize this to promote collaborative research.

- **Quantum Sensors**

A sensor is a device that converts a physical phenomenon or the state of an object into an electrical signal. In particular, a sensor that uses the quantum effect (a phenomenon that appears in quantum mechanics) is called a quantum sensor. These quantum sensors are expected to detect with greater sensitivity than conventional sensors and to contribute to the construction of an ultra-smart society by detecting phenomena that were previously undetectable.

Although there are various types of quantum sensors, we are particularly interested in SQUID (Superconducting Quantum Interference Device) sensors, which can detect very small magnetic fields. In order to develop SQUID sensors that are smaller and can operate at higher temperatures, in the 2023 academic year, as in the past, we continued developing high-temperature superconductors with a thickness of several atomic layers. We focused on the change in superconducting properties when tellurium (Te) atoms were mixed into a monolayer iron selenium (FeSe) thin film on a strontium titanate ($SrTiO_3$) substrate. This material has a special superconducting state called topological superconductivity and possesses Majorana quasiparticles, which could also be applied to the next generation of topological quantum computers. As a result of precise measurements by students enrolled in the WISE Program, data that can be considered a sign of Majorana quasiparticles was obtained and a master's thesis was written. Going forward, we plan to carry out more detailed measurements as doctoral research.

In collaboration with Consortium Partners, from the 2021 academic year, we began searching for optimal surface oxidation conditions aimed at the development of new quantum sensors. These quantum sensors utilize oxygen defects on the surface of silicon carbide (SiC) crystals, which are wide-gap semiconductors. Last academic year, we discovered that the luminescence characteristics after oxidation differ depending on the periodic structure of the SiC surface before oxidation. This academic year, we attempted to identify these luminescence defects through atomic-scale measurements using a scanning tunneling microscope. Although we are still only partway in these efforts, we hope that clarifying this issue will lead to the development of quantum sensors using SiC.

Moreover, we used the installed equipment to hold One-day School for young employees of Consortium Partners (Figure 4-18). Participants commented that the program provided a foothold for further individual study. In this way, in the Quantum Sensor R&E field, we are cultivating human resources and conducting education in quantum science at the same time as performing research. We hope that companies and national research institutes will take advantage of this field.

4.2.4. Artificial Intelligence

In a super-smart society, we expect every device that we use in our daily lives will become smart and connected to computers, resulting in a safer and more convenient life. An essential item for control by computers is a system that can operate by recognizing and understanding surrounding conditions via sensors and cameras. Much of the information in the physical world is noisy and unclear. Therefore, in order to properly process these in the cyber world, it must be converted into symbolic information that is easy for computers to process. At the Tokyo Tech Academy for Super Smart Society, we consider artificial intelligence technology to be a basic technology that can connect the cyber and physical worlds in a super smart society. Therefore, we are providing education with the aim of enabling enrolled students to master artificial intelligence technologies. Starting in the 2020 academic year, Tokyo Tech has begun university-wide Data Science and Artificial Intelligence (DSAI) education for graduate students. Unlike existing classroom-only lessons, this allows students to practice while actually operating machine learning tools in a practical environment. For this purpose, the Academy started the operation of an education system using Wi-Fi 6 from the 2020 academic year. To ensure the efficient use of "deep neural networks," there is the need for an advanced computational environment equipped with GPUs (Graphics Processing Units). At present, GPUs are too expensive for all students to purchase, but by using cloud-based services it is possible to provide a similar computing environment to all students at low cost. With this educational system, students can easily access the cloud-based learning environment via Wi-Fi using their own PCs. On the cloud, it is possible to actually try handling the materials and themes presented by the teacher as a "moving textbook" using a service called Google Colaboratory[Note 3], thus making it possible for students to learn comfortably (Figure 4-19). This also allows the GPU of the university's supercomputer TSUBAME (Figure 4-20) to be used.

Our institute requires that students who graduate must have a certain level of knowledge about artificial intelligence. For students who are even more motivated, we have been holding intensive exercises in interdisciplinary research planning using

Figure 4-18 One-day School on Quantum Sensors

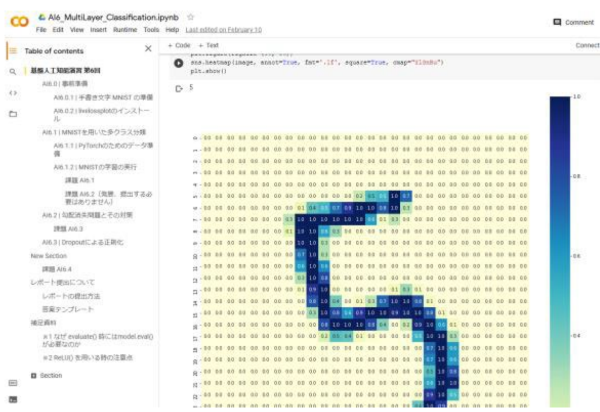


Figure 4-19 Google Colaboratory

artificial intelligence for registered students of our institute since 2020. Here, each student can learn about the latest research results directly from Tokyo Tech faculty members through demonstrations. By doing so, we aim to further improve the skills of the students. In September 2022, we held a lecture on neural net technology and performed practical exercises based on image recognition tasks. We also held a presentation of learning results.

Furthermore, in the 2023 academic year, continuing from 2022, we held a One-day School for Consortium Partners. A total of four attendees participated. At the One-day School, we explained the principle of neural networks and basic usage of Google Colaboratory. We also conducted simple exercises using PyTorch(Note 4). In the exercises, students worked on two common tasks (image style transformation and sentence generation using large-scale language models) and three elective tasks (PyTorch basics, image and speech recognition, and reinforcement learning).

(Note 3) Google Colaboratory:
A development environment for machine learning education and research provided by Google

(Note 4) PyTorch: Python's open source machine learning library used in computer vision and natural language processing.

Figure 4-20 TSUBAME

4.2.5. Smart Workplace

In this R&E field, we are building a platform based on the theme of a "smart workplace" with the goal of creating a place where each individual can work in a healthy and vibrant manner.

In the 2023 academic year, we conducted experiments to estimate metabolic rate. These experiments were aimed at further advancing the thermal comfort assessment system using thermal images and AI, which we had been developing until the 2022 academic year. We performed simultaneous measurement of a mask-type exhaled gas metabolic rate meter and thermal images (Figure 4-21) and checked the correlation between the two variables. We found a certain degree of positive correlation between metabolic rate and body surface temperature measured by thermal images. Taking these results into consideration, we plan to conduct another experiment in the next academic year on human-centered air conditioning using thermal imaging and AI.

In addition, continuing from the 2022 academic year, we conducted a subject experiment using the "Smart Work Home," a field that replicated a work-from-home environment constructed at Tokyo Tech Suzukakedai Campus (Figure 4-22). This experiment evaluated the impact of indoor greenery on the physiological responses of people working from home. We found that workers who have a positive impression of indoor plants tended to have lower stress.

We also conducted a long-term demonstration experiment on "predicting the deterioration of office workers' health" over a four-month period at the offices of Consortium Partners. The experiment targeted 50 office workers. In the next academic year, we plan to continue analyzing the results of this experiment and to use our findings as a starting point for further studies on the interaction of workplaces and healthcare.

In the 2023 academic year, we also focused on disseminating our findings to date at events such as academic conferences. The results of our sleep experiments in smart work homes were published in the international academic journal *Indoor Air*[1] and were also presented at various academic conferences, including the Architectural Institute of Japan and The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan. At the CYBERNET Solution Forum 2023, we introduced COVID-19 airborne infection prevention measures using Fluent and mixed reality.

In the 2024 academic year, with an eye toward the upcoming university merger, we plan to continue considering ways to better contribute to worker healthcare.

[1] Kondo K, Asawa T. Experimental Study on Sleep Quality in Naturally Ventilated Rooms under Moderate Climate Conditions. *Indoor Air* 2023: 8853643

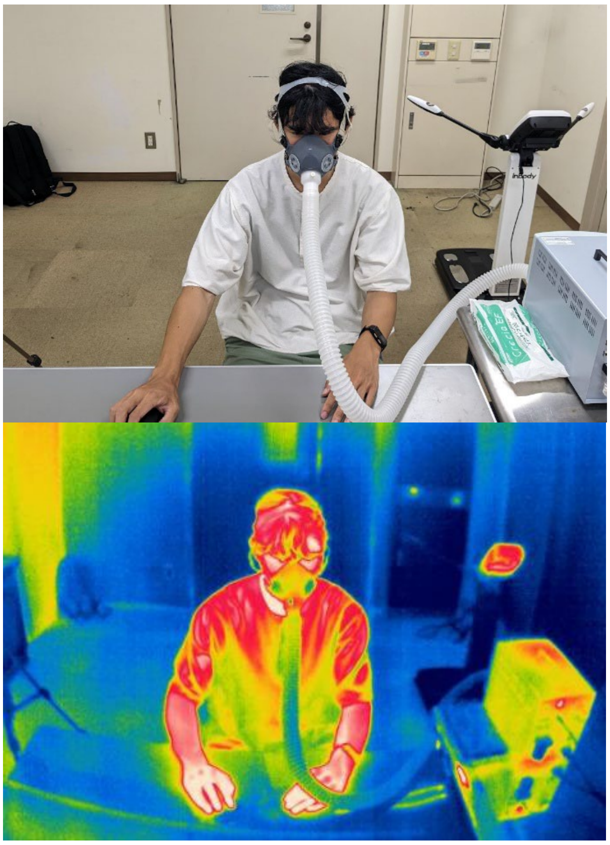


Figure 4-21 Experiment on metabolic rate estimation using a thermal comfort evaluation system

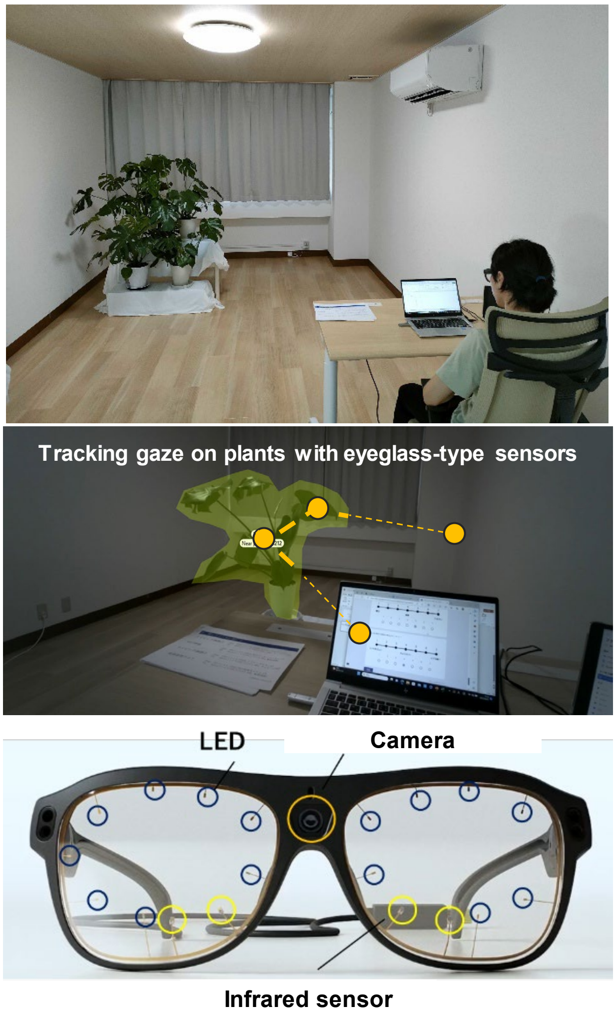


Figure 4-22 Subject experiment on indoor greenery and physiological responses

4.2.6. Smart Agriculture

The Smart Agriculture R&E field provides a platform for education and research on cutting-edge technologies to realize sustainable, high-yield, unmanned smart agriculture, including off-grid systems and automated cultivation techniques. In order to solve challenges faced by Japanese farms (for example, shrinking population of farmers and the difficulty in increasing efficiency due to the large amount of small farmland in mountainous areas), we are cultivating human resources and developing technologies such as remote farming, which can be done unmanned. Our research and development field utilizes Tokyo Tech's strengths in advanced technologies such as robotics, ICT, and AI. This field is also an agricultural site where the symbiosis between crops and soil microorganisms is continuously observed in order to realize sustainable agriculture that does not exhaust the land through agriculture.

In early spring of the 2023 academic year, we and improved the soil by cultivating and tilling oats, which is a green manure crop, and applying cow manure at the outdoor smart agriculture R&E field on the Suzukakedai Campus of Tokyo Tech. The soybeans grown there showed significantly improved growth conditions compared to the 2022 academic year, which was before we made soil improvements. We have confirmed that indicators of soil biodiversity are now comparable to other organic farms. We also developed a system that periodically transmits environmental and image data from the sensor network to a remote server for storage. Furthermore, we installed a satellite internet access service (Starlink[Note 5]) and operated it using only power from the tracking solar power generation system which we installed in the 2022 academic year. We have confirmed that it is possible to achieve sufficient off-grid electricity and communications infrastructure for smart agriculture (Figure 4-23). In collaboration with Smart Robotics (Robot Zoo Sky), we conducted a demonstration experiment of efficient drone flight control for reconstructing the 3D structure of crops grown outdoors based on aerial images. In the 2024 academic year, we plan to build a completely off-grid system (tracking solar power generation, automatic irrigation equipment using rainwater, and Starlink), demonstrate aerial photography control and aerial image processing technology, develop ground robots for automatic sensing, and periodically observe soil microorganisms.

On September 26, we held the 8th Super Smart Society Promotion Forum on the Suzukakedai Campus. The forum was entitled "Re-Engineering of Agriculture towards Super Smart Society." Participants from inside and outside of Tokyo Tech were given tours of the outdoor smart agriculture R&E field, where drone aerial photography, demonstrations of agricultural robots, and an introduction to off-grid systems were also held (Figure 4-24). Tokyo Tech's efforts focusing on smart agriculture, including the smart agriculture R&E field, were published in an article entitled "Participation by 62

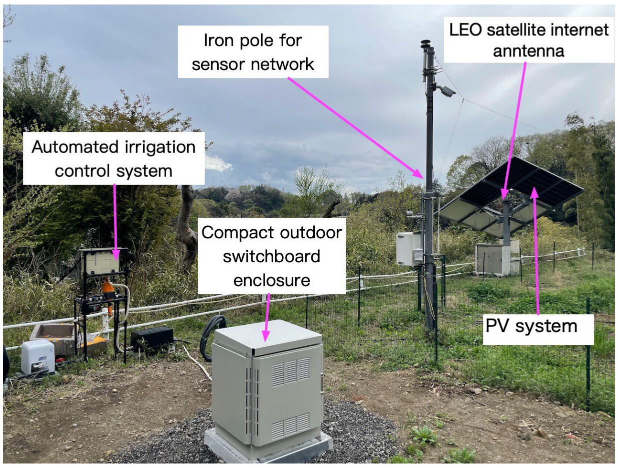


Figure 4-23 Off-grid system

Figure 4-24 Smart Agriculture Education and Research fields tour of the 8th Super Smart Society Promotion Forum (demonstration of agricultural robot)

Organizations: Tokyo Tech Leads a Consortium for Sustainable Agriculture Future" (March 15, Kodansha, *Gendai Business*).

In the 2023 academic year, a group of instructors composed of members of the Super Smart Society Promotion Consortium held a lecture entitled "Frontiers in Smart Agriculture," which has been an ongoing lecture series since the 2021 academic year. We also held intensive exercises in interdisciplinary research planning on September 21 for students participating in this educational program, and held a One-day School for Consortium Partners on October 10. In the 2024 academic year, we will continue to hold the lecture "Frontiers in Smart Agriculture," the intensive exercises in interdisciplinary research planning, and the One-day School. Through these lectures and practical training in the smart agriculture R&E field, students can study the future of Japanese-style smart agriculture and cutting-edge practical examples for its realization.

(Note 5) Starlink: Satellite broadband internet system developed by SpaceX.

4.2.7. Smart Infrastructure Maintenance

Proper maintenance of infrastructure, which is the foundation that supports our lives, industries, etc., is essential for ensuring urban functions and resilience. The Tokyo Institute of Technology has also established Sustainable Social Infrastructure (SSI) as one of our strategic areas. This R&E field conducts activities aimed at developing and demonstrating the technologies that will be necessary in the future, such as inspection and investigation, evaluation technology, and repair and reinforcement, in order to make infrastructure maintenance smarter, which will be important in realizing a Super Smart Society.

This R&E field consists of an on-campus laboratory for the development of individual underlying technologies through

Figure 4-25 Actual structure field (Fujimi bridge)

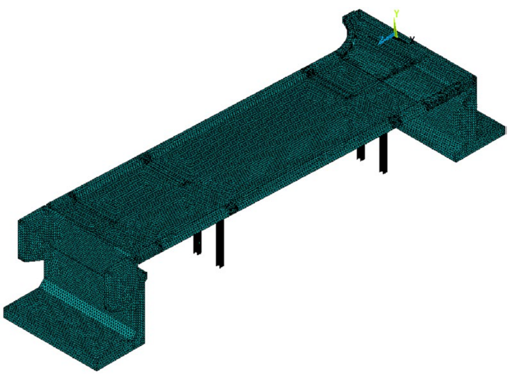


Figure 4-26 Digital twin model construction (Fujimi bridge)

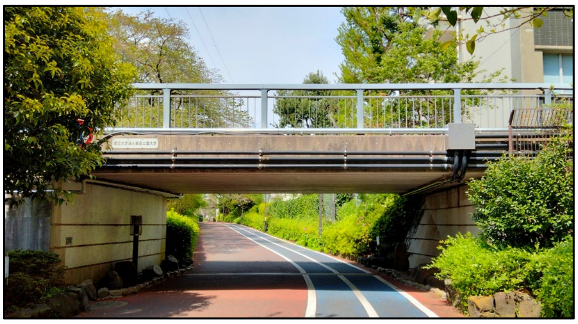


Figure 4-27 Actual structure field (Todoroki bridge)

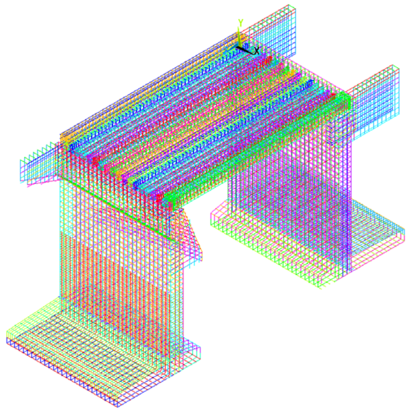


Figure 4-28 Digital twin model construction (Todoroki bridge)

experiments, and real structure fields for demonstrations and exercises of development technology and advanced technologies. The real structure fields are expected to serve as places to deploy various technologies targeting bridges, tunnels, and other infrastructure that actually exist on campus.

In the 2023 academic year, we promoted the creation of real structure fields and installed a system capable of continuously measuring acceleration and other parameters for three structures on campus (Fujimi Bridge (Figure 4-25), Todoroki Bridge (Figure 4-27), and the Ishikawadai Area Tunnel). We are conducting joint research using the real structure field for the Fujimi Bridge and operating a measurement system to track the health of the information conduit.

Based on acceleration and other measurement data introduced into each real structure field, we are promoting technologies for analyzing the condition of each structure, building digital models (Figure 4-26, Figure 4-28) that replicate the characteristics of each structure, tracking the environment in which the structure is used (weight of passing vehicles, etc.), analyzing its behavior during earthquakes, and studying damage indexes. Figure 4-29 shows the conditions of a loading test conducted using a passenger car to understand structural behavior. In particular, in the 2023 academic year, we built digital models of the Fujimi Bridge and Todoroki Bridge, including their substructures. We then used measurement data to estimate the structural parameters of the bridges, with the ultimate aim of developing and applying methods for understanding the condition of structures. We also use a 3D scanner to acquire point cloud data and obtain information on the location of actual structures.

We are holding discussions on systems that link physical

Figure 4-29 Vehicle loading test (Todoroki bridge)

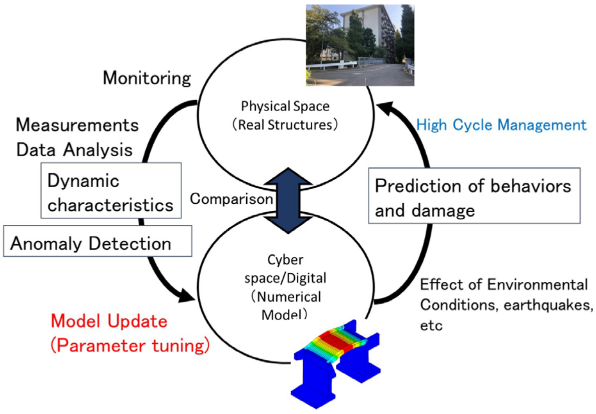


Figure 4-30 Concept of digital twin model construction

Figure 4-31 High-rise seismically isolated building (Building J2-3, Suzukakedai campus)

spaces and cyberspaces, thereby making it possible to understand and manage the state of structures using highly reproducible digital models (digital twin models) (Figure 4-30).

In the 2024 academic year, we plan to study the impact of temperature-related changes on the characteristics of Fujimi Bridge and Todoroki Bridge, as well as on their behavior during earthquakes. We also plan to develop digital twin models of the real structures in the field for the Ishikawadai Area Tunnel, and study the application of maintenance technologies. These efforts have led to consideration of practical implementation, as well as consideration of inspection, repair and reinforcement methods.

4.2.8. Smart Buildings

This R&E field is a research platform for the evaluation of building safety and continuity of use during earthquakes and typhoons using high performance sensors densely installed in buildings, and for early notification methods for occupants. We aim to contribute to improving the resilience of not only buildings but also urban functions.

We have completed the installation of 2-channel anemometers and 84-channel acceleration, displacement, and strain sensors on the roof (Figures. 4-32 and 4-33) and 17-channel accelerometers on the ceiling and non-structural walls of a high-rise seismically isolated building (Building J2-3, Figure 4-31) on the Suzukakedai Campus of Tokyo Tech. We have already built a system that allows those data to be viewed on computers and smartphones via the Internet. The system is used for constant observation.

This academic year, we analyzed the vibration characteristics of non-structural walls during earthquakes (Figure 4-34). Unlike structural components such as columns and beams, nonstructural walls do not support the load of the building, so the building will not collapse even if nonstructural walls are damaged. However, if a nonstructural wall is damaged, the room

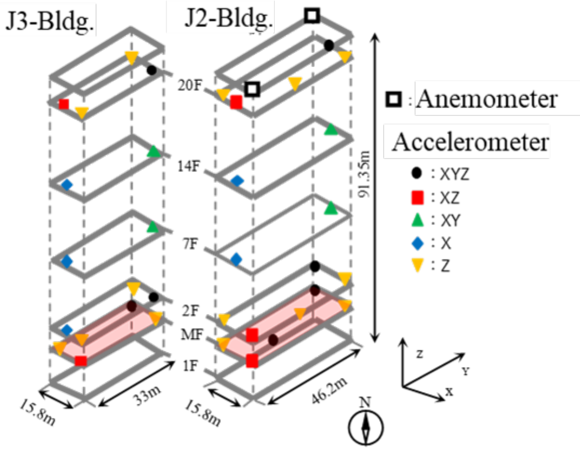


Figure 4-32 Locations of anemometers and accelerometers

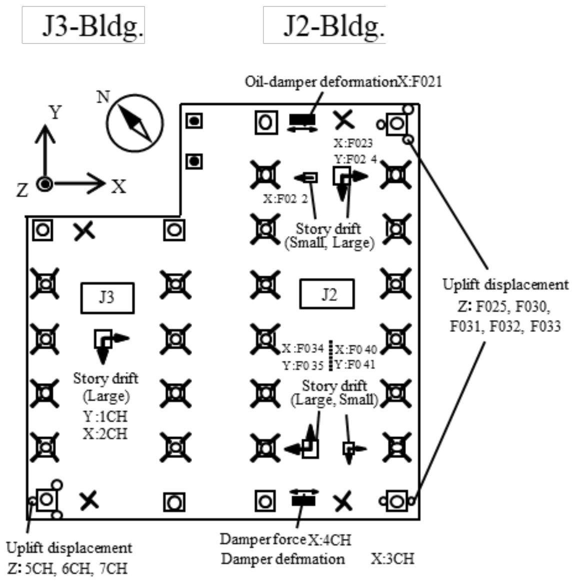


Figure 4-33 Locations of displacement sensors

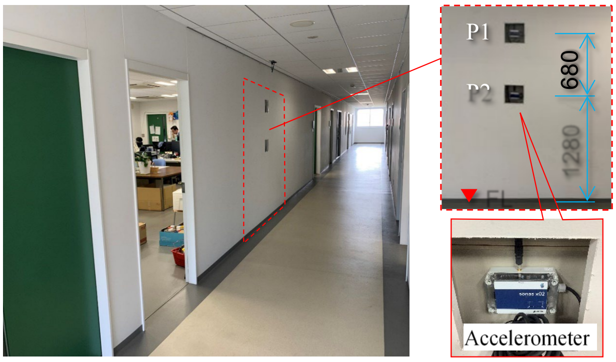


Figure 4-34 Measurement of the non-structural wall on 7th floor

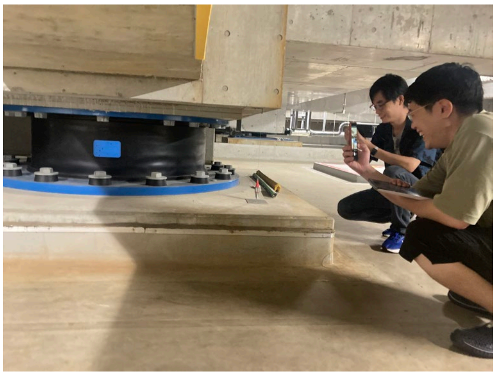


Figure 4-37 Tour of the seismic isolation layer of J2-3 building

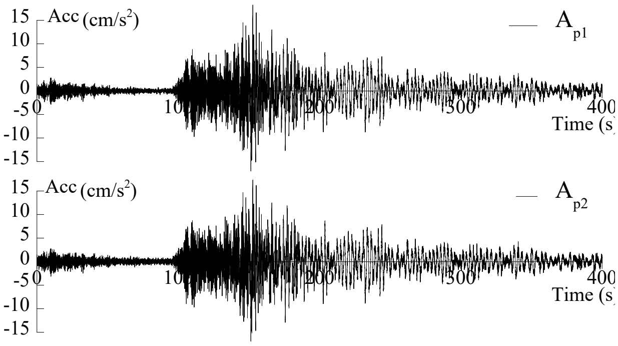


Figure 4-35 Acceleration time history measured on the non-structural wall (top: P1, bottom: P2)

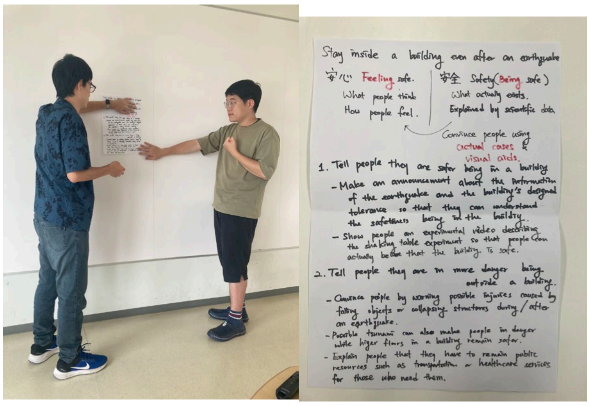


Figure 4-38 Workshop (left) and report (right)

or corridor can no longer be used. For this reason, the seismic performance of nonstructural walls has been attracting attention in recent years. Even so, the seismic response of nonstructural walls installed in actual buildings is not measured in this field. Therefore, the value which we obtained was extremely valuable (Figure 4-35). Non-structural walls experience the same level of

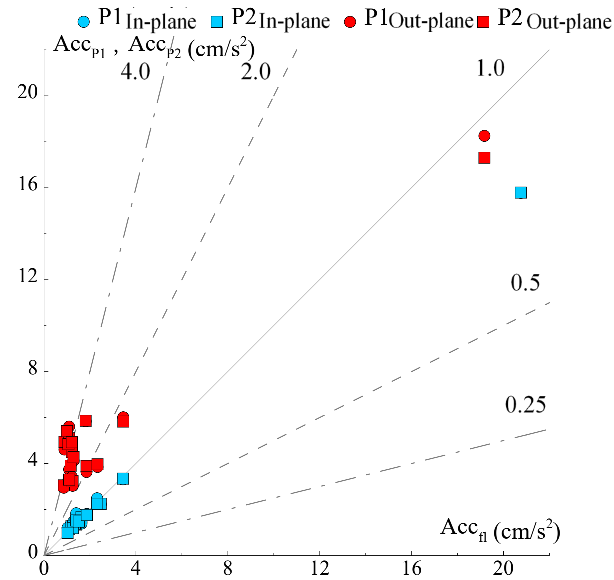


Figure 4-36 Comparison of maximum accelerations between the floor and the non-structural wall (13 records)

acceleration in the in-plane direction relative to the floor. However, there have been cases where acceleration increases by about four times in the out-of-plane direction (Figure 4-36).

In October 2023, we held intensive exercises in interdisciplinary research planning for the 2023 academic year. The contents of those exercises were touring the J2-J3 buildings (Figure 4-37), where participants learned about seismic isolation structures and monitoring using sensors. Afterwards, we held a workshop with students entitled “How Can We Alleviate Concerns Felt by Residents During an Earthquake?” (Figure 4-38). We plan to use these results to assist in future research which focuses on how to communicate with residents in a way that alleviates their concerns.

4.2.9. Smart Ocean

A wide variety of industrial sectors (fisheries, shipping, resources, energy, leisure, etc.) are active in the ocean. Many ocean issues are becoming apparent, including climate change, the depletion of fishery resources, and the decline of biodiversity. Smart Ocean aims to quantify and visualize the flow of information in the ocean and demonstrate optimization technologies for sustainable ocean use.

In the 2023 academic year, together with institutions participating in the Smart Ocean Subcommittee, we reviewed the overall concept of Smart Ocean and established a specific field for realization. We also began observations in some areas.

The overall concept of Smart Ocean focuses on the fishing industry in particular. The concept creates a vision to maximize value created by the fishing industry by exchanging information to optimize distribution at each stage of the seafood supply chain, from fishing sites to the consumer (Figure 4-39). Taking

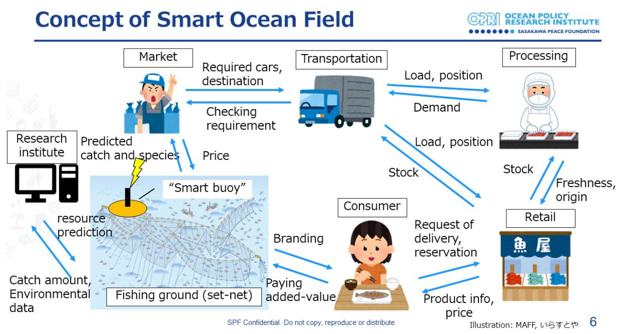


Figure 4-39 Conceptual image of Smart Ocean Research and Education field

into account the expertise and past experience of the Consortium Partners, we discussed the areas of contribution of each organization in line with the overall concept and created a proposal structure.

The specific field we chose was Suruga Bay in Shizuoka Prefecture. The advantages of Suruga Bay as a R&E field include: 1) good logistics access to the Tokyo metropolitan area, which is a major consumer region; 2) deep waters and high biodiversity; and 3) operation of several marine-related industries (fisheries, marine logistics, etc.) on a moderate scale. In light of these advantages, we have decided to conduct cross-sectoral and cross-industry smart ocean demonstration projects in Suruga Bay and the surrounding areas.

As a specific activity in the 2023 academic year, with the cooperation of Koden Electronics Co., Ltd. and NITTO SEIMO CO., LTD., we installed a ubiquitous fish finder in a fixed net set up in the Yui area of Shizuoka Prefecture (Figure 4-40). By using 4G lines for remote monitoring of sonar images from inside set nets, we aim to contribute to the efficiency and optimization of fishing. For example, our data will facilitate decisions on when to leave port to fish, how much ice to prepare, and ultimately how to manage resources. Going forward, we will review the use of deep learning to classify fish species and to collaborate with markets, distributors, and retailers.

Additionally, the Nakashima Laboratory at Tokyo Tech conducted biomechanical research on the diving movements of an Ama (a professional female diver) in collaboration with the Mie University Ama Research Center (Figure 4-41). We expect

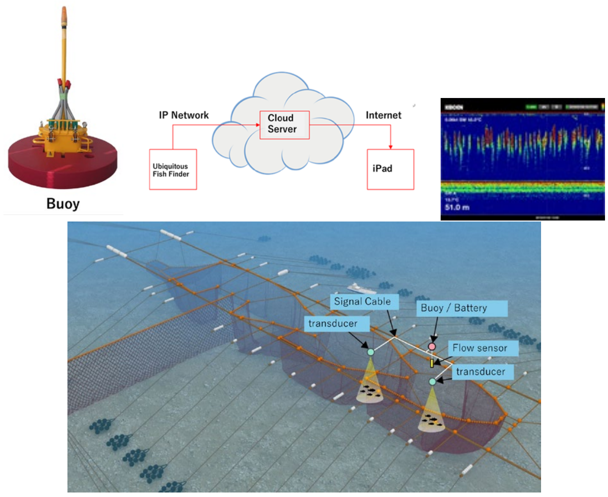


Figure 4-40 Ubiquitous fish finder

this research to lead to more efficient transfer of technology and improved safety in free-diving training and lectures.

In the 2024 academic year, we are working to visualize added value by analyzing the acquired data. We will begin efforts to optimize the supply chain by combining information distribution and logistics. We also plan courses related to Super Smart Society Innovation under the theme of smart ocean. We hope to contribute to the progress of smart ocean technology, which has been noted as lagging behind land-based efforts, and to help as many students as possible discover the appeal of the ocean.

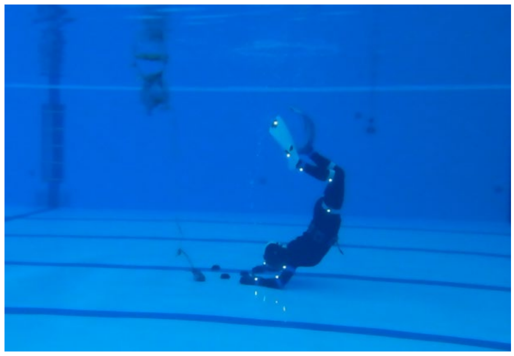


Figure 4-41 Measurement of diving motion

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Vice President for Global Communication
Professor, Dept. of Mechanical Engineering, School of Engineering
Field of Specialization：Synthesis and Control of Robotic Mechanisms, Acoustic environment, Actuator.

Coordinator

Kei Sakaguchi
Dean, Tokyo Tech Academy for Super Smart Society
Professor, Dept. of Electrical and Electronic Engineering, School of Engineering
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Vice Coordinator

Kenichi Okada
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Super Smart Society Promotion Committee Chair and Overall secretary

Eisuke Fukuda
Specially Appointed Professor, School of Engineering
Field of Specialization：Wireless network, device for wireless communications

Social Collaborative Education Steering Committee Chair

Mitsuji Sampei
Professor, Dept. of Systems and Control Engineering, School of Engineering
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Interdisciplinary Research Promotion Committee Chair

Koichi Shinoda
Professor, Dept. of Computer Science, School of Computing
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Mitsuyasu Iwanami
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Koichi Suzumori
Professor, Dept. of Mechanical Engineering, School of Engineering
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Tetsuo Kodera
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