Annual Report 2025

Research Institute of Electrical Communication
Tohoku University

Annual report of Research Institute of Electrical Communication 2025

Contents

1. Introduction

The mission of the Research Institute of Electrical Communication (RIEC) is “To realize a new paradigm of communications that enriches people’s lives.” Communication is an extremely important element of human society. Information and communication technology, which is the subject of research and development at the institute, has greatly changed the nature of communication throughout its history, enabling information exchange that exceeds human limitations in terms of speed, quantity, and quality. Communication (information and communication) in the modern age has expanded its forms from “person to person” to “person to thing” and “thing to thing,” and has also extended the limits of space and time, and continues to develop into diversity. Furthermore, the scope of information and communication research has been extended to the mechanism by which the human brain understands the information it receives. RIEC continues its activities with the aim of contributing to the academic and social prosperity of Japan and to the welfare of human society at large, in order to realize a prosperous information society.

Society's demands for information and communication technology are becoming stronger and more diverse. Among them, it is expected to further strengthen and promote new functional devices such as cyber security, next-generation information and communication (Beyond 5G), quantum computing, AI (artificial intelligence), and spintronics, which are important fundamental technologies. These are research areas in which RIEC should lead the way, and these are themes that we should focus on in order to contribute to the demands of the times. On the other hand, Dr. Junichi Nishizawa, the 9th Director of RIEC and the 17th President of Tohoku University, once said that academia must start research from where it does not yet have a name. This means that basic research and fundamental research based on the free ideas of faculty members are an extremely important role of universities. Basic research is to find a bright light that shines out of chaos, and to refine and nurture it. Looking back on the history of RIEC, there are many examples of fundamental research that opened completely new fields, such as the three elements of optical communication, and the perpendicular magnetic recording and magnetoresistive memory (MRAM), which have since made great strides. RIEC will continue its activities with the aim of contributing to the academic and social prosperity of Japan and to the welfare of humanity at large, while listening to the

demands of society from time to time and aiming to realize a prosperous information society in the future.

The institute's organizational structure has been organized into three units: three research divisions (Computing System Platforms Division, Information Communication Platforms Division, and Human and Information Systems Division), two laboratories (Laboratory for Nanoelectronics and Spintronics, and Laboratory for Brainware Systems), and two research centers (research center for 21st Century Information Technology and interdisciplinary ICT research center for Cyber and Real Spaces). These units are engaged in research aimed at achieving fruition over different time scales (Research Divisions: 20 years, Laboratories: 10 years, Research Center: 5 years). In addition, the first Co-Creation Research Institute, which promotes industry-academia collaboration, has been established in April 2023 (during three tears), and the "Research Center for Comprehensive Knowledge Informatics" has been newly established in fiscal year 2024, led by the members of the institute, following the Ministry of Education, Culture, Sports, Science and Technology (MEXT) for budgetary allocation. We also collaborate closely with Tohoku University's graduate schools in subjects relating to electrical engineering (School of Engineering, Graduate School of Information Sciences, and Graduate School of Biomedical Engineering) in order to cover a wide range of cutting-edge research fields and foster the development of outstanding researchers and engineers.

The Institute is organized into three research divisions, Computational Systems Infrastructure, Information and Communication Infrastructure, and Human and Biological Information Systems (from April 2023), two facilities, the Nano-Spin Experimental Facility and the Brainware R&D Facility, the 21st Century Information and Communication R&D Center and the Interdisciplinary ICT Research Center for Cyber and Real Spaces (from April 2023). These units are engaged in research aimed at achieving fruition over different time scales (Research Divisions: 20 years, Laboratories: 10 years, Research Center: 5 years). In addition, the first Co-Creation Research Institute, which promotes industry-academia collaboration, was established in April 2023, and the "Research Center for Comprehensive Intelligence and Informatics" was newly established in fiscal year 2024, led by members of RIEC, following the Ministry of Education, Culture, Sports, Science and Technology (MEXT) for budgetary allocation. In addition, RIEC works closely with the Graduate Schools of Engineering, Information Science, and Biomedical Engineering, and has established a system to cover a wide range

of cutting-edge research fields and to produce outstanding researchers and engineers.

The Institute has also been accredited by MEXT as a Joint Usage/Collaborative Research Center for Information and Communication, and is continuing its third phase of activities from FY2022. As operating subsidies decrease, the role of RIEC in leading the information and telecommunications community in Japan and abroad becomes increasingly important. As a research hub, RIEC conducts approximately 130 collaborative research projects each year with external researchers and engineers from industry, government, and academia. Moreover, following Tohoku University's official accreditation as a University for International Research Excellence, we have successfully recruited two exceptional young researchers from domestic and international talent pools for academic year 2025, which will further accelerate our research initiatives.

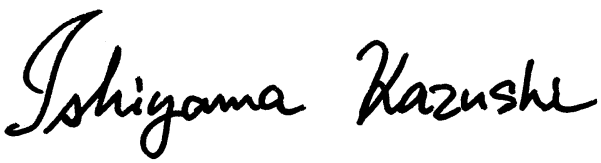
We will continue to address these social needs by fully leveraging our strengths as a university-affiliated research center. In doing so, we hope to forge the path to a new world of communication, and through these efforts continue to promote education going forward.

To contribute to the improvement of our research activities and support future developments, we publish this Annual Report every year to make our activities relating to research, education, and social contribution widely available for public scrutiny. This edition contains reports on a range of activities, including the research conducted by each of our departments and laboratories, collaborative research projects, international activities, social contributions, the RIEC symposia, activities of the engineering research association, and RIEC lectures. The bibliography section also includes data on the various activities we have conducted over the last five years.

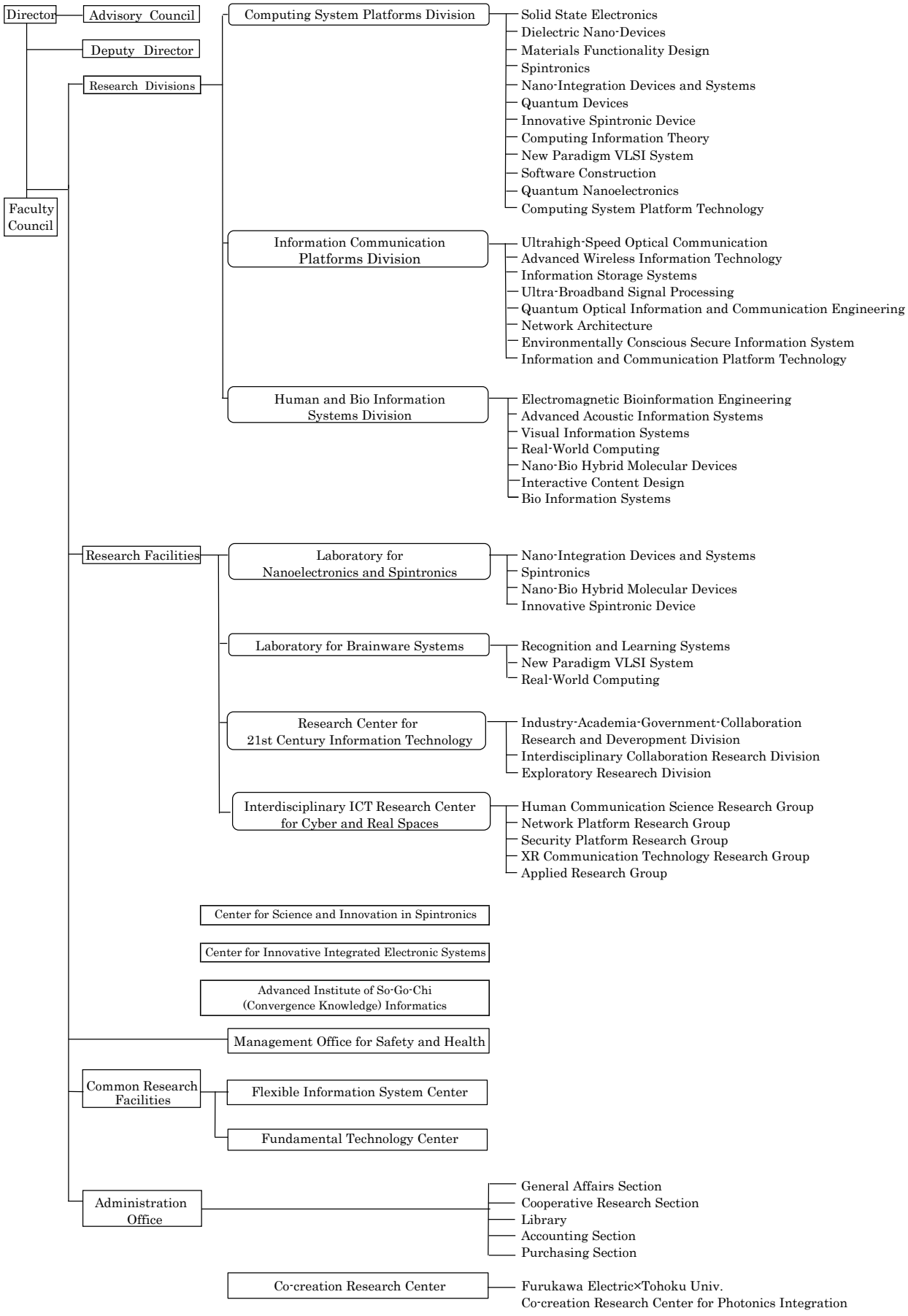
We welcome your frank opinions regarding our activities and look forward to your continued guidance and support in the future.

2026

Kazushi ISHIYAMA
Director, Research Institute of Electrical Communication



2. Organization Chart



3. Research Activities

Targets and achievements of the Computing System Platform Division

The computing system platform division is conducting research by vertically integrating the scientific areas ranging from condensed-matter physics and material science to devices, processes, circuits, systems, and software to acquire the "Transcendent Computational Capability" that is one of the three significant challenges in the "RIEC Future Vision" set in 2021. The research in this division will lead to the construction of technology to address computationally challenging problems with high speed and low energy, which are difficult for the conventional computing scheme to address. To this end, we conduct research to establish a fundamental understanding of designing devices, circuits, and software and develop new functional information devices and systems. We aim to realize semiconductor/ dielectric/ quantum/ and spintronic devices that utilize new functionalities emerged in novel materials and nanostructures, new-paradigm semiconductor circuits based on unconventional design principles and devices, and to improve the dependability of software.

The following 12 laboratories are conducting research and developments to achieve the goal.

1. Solid State Electronics
2. Dielectric Nano-Devices
3. Materials Functionality Design
4. Spintronics
5. Nano-Integration Devices and Systems
6. Quantum Devices
7. Innovative Spintronic Device
8. Computing Information Theory
9. New Paradigm VLSI System
10. Software Construction
11. Quantum Nanoelectronics
12. Computing System Platform (Visitor Section)

The research target and the summary of activities of each sub-division in FY2025 are described in the following pages.

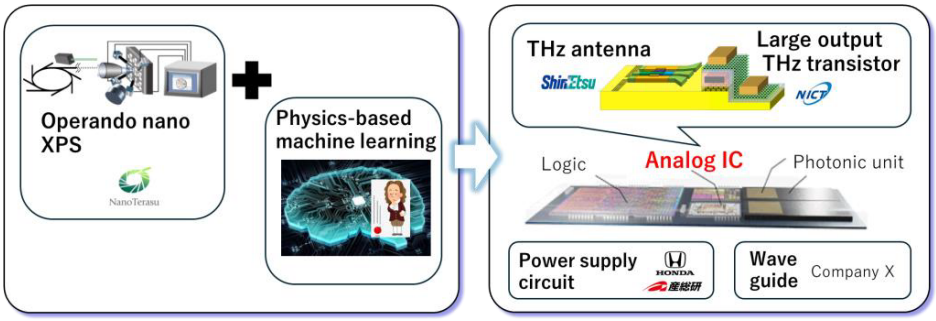
Solid State Electronics Laboratory

Development of Ultimate Transistors and an Advanced Research Platform for Devices and Circuits

Solid State Physics for Electronics　Hirokazu Fukidome, Associate Professor

[Research Target and Activities]

We aim to realize the ultimate transistor with a gate length scaled down to the monoatomic scale, and to apply it to integrated circuits. At the same time, we are developing *device informatics (DI)*—a new framework that links material properties to device functions using big data obtained through operando X-ray nanospectroscopy. In FY2025, we successfully demonstrated the operation of a transistor with an atomically thin channel and an atomically short gate fabricated by the orthogonal growth of graphene and two-dimensional semiconductors. Furthermore, we advanced a topology-based machine-learning approach and successfully applied topological data analysis to the graphene crystal growth process, quantitatively visualizing the relationship between structural evolution and energy variation. In addition, in collaboration with companies such as Shin-Etsu Chemical and Honda, we promoted industry–academia–government joint research utilizing the NanoTerasu synchrotron facility. This initiative led to the establishment of a globally unique, large-scale research framework spanning materials, devices, and final products.



Overview of our research activities.

[Staff]

Associate Professor：Hirokazu Fukidome, Dr.
Technical Assistant：Fuminori Sasaki, Mr.
Technical Assistant：Kumi Nami, Mrs.
Technical Assistant：Miyuki Fukagawa, Mrs.

[Profile]

Hirokazu Fukidome received a Ph.D. in chemistry from Osaka University. After working at Bell Labs and RIKEN, he became assistant professor at RIEC in 2008. He has been an associate professor at RIEC since 2012. He has conducted research on 2D Dirac electron systems and their operando-microscopy analysis. He was awarded the Best Paper Award from the Surface Science Society of Japan in 2011, M. Ishida Research Foundation Award in 2015, and RIEC Award in 2016.

[Papers]

[1] Y. Igarashi, N. Nagamura, M. Sekine, H. Fukidome, H. Hino and M. Okada, “Sparse Coding-Based Multiframe Superresolution for Efficient Synchrotron Radiation Microspectroscopy”, Discover Nano, 20, 102-1-102-20 (2025).
[2] M. Tone, S. Sato, S. Kunii, I. Obayashi, Y. Hiraoka, Y. Ogawa, H. Fukidome, A. L. Foggiatto, C. Mitsumata, R. Nagaoka, A. Varadwaj, I. Matsuda and M. Kotsugi, “Linking structure and process in dendritic growth using persistent homology with energy analysis”, Science and Technology of Advanced Materials: Methods, 5, 2475735−1− 2475735−12 (2025).
[3] Takashi Uchino, Yanjun Heng, Chao Tang, Shigenobu Kasai, Hirokazu Fukidome, Akira Satou, Shuji Ikeda, Taiichi Otsuji, “Improved sensitivity in graphene-mediated surface-enhanced Raman scattering via H_2/Ar annealing”, Journal of Applied Physics 138, 174503-1-174503-9 (2025).

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Dielectric Nano-Devices

Research on Dielectric Nano Science and Technology

Dielectric Nanoscale Measurement Systems Kohei YAMASUE, Associate Professor
Dielectric Materials Science and Engineering Yoshiomi HIRANAGA, Associate Professor

[Research Target and Activities]

Our main area of interest is evaluation and development of dielectric materials, including ferroelectric and piezoelectric materials and their application to communication devices and ferroelectric data storage systems. Our major contributions to advancement in these fields are the invention and the development of "Scanning Nonlinear Dielectric Microscope" (SNDM) which is the first successful purely electrical method for observing the ferroelectric polarization distribution and it has already been put into practical use. The resolution of the microscope has been improved up to atomic scale-order. Therefore, it has a great potential for realizing the ultra-high density ferroelectric recording system. In addition, SNDM can be used for the evaluation of various semiconductor materials and devices.

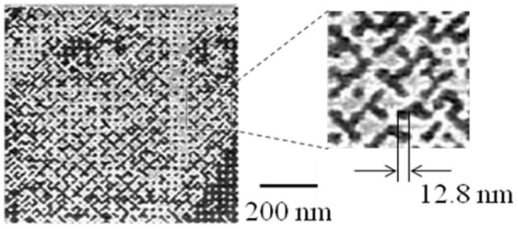

Fig.1 Digital bit data written on ferroelectric single crystal with the areal recording density of 4 Tbit/inch^2.

Major achievements of studies in 2025 are as follows: (1) We extended the system to enable local DLTS and CV measurements at high temperatures toward the realization of time-resolved SNDM-based microspectroscopy. We also developed a variable-sweep-time local CV measurement method and light-assisted time-resolved SNDM. (2) Local C–V mapping measurements were performed on samples in which nanoelectrodes with diameters of approximately 100 nm were fabricated on the surface of ferroelectric single crystals, thereby clarifying the quantitative capability of this method. (3) Local C–V mapping measurements were also performed on ferroelectric $Hf_{0.5}Zr_{0.5}O_2$ thin films before and after cyclic electric-field application, successfully providing useful insights into mechanisms such as polarization fatigue, which remains a key issue for electronic device applications of this material.

[Staff]

Associate Professor : Kohei Yamasue, Ph. D.
Associate Professor: Yoshiomi Hiranaga, Ph. D.

[Profile]

Kohei Yamasue received the Ph. D degree in engineering from Kyoto University in 2007. He then became a postdoctoral fellow in 2007 and an assistant professor in 2008 at Venture Business Laboratory, Kyoto University. In 2010, he joined Research Institute of Electrical Communication, Tohoku University, as an assistant professor and, in 2016, became an associate professor. His main interests include the development of noncontact scanning nonlinear dielectric microscopy and potentiometry with atomic-resolution. He also works on the development of multifunctional time-resolved scanning probe microspectroscopy system for the evaluation of the next-generation electronic materials and devices.

Yoshiomi Hiranaga received the Ph. D degree in engineering from Tohoku University in 2006. He then became a research associate in 2006 (2007- assistant professor) at Research Institute of Electrical Communication, Tohoku University, and became an associate professor in 2020. His main interests include domain switching phenomena on ferroelectric materials in the nanoscale area and their applications for next-generation high-density data storage devices.

[Papers]

[1] K. Takano, K. Yamause, T. Kato, and Y. Cho, Appl. Phys. Lett., Vol. 128, Art. No. 052101 (2026) [Editor's pick]
[2] K. Yamasue, K. Takano, T. Ishizuka, and Y. Cho, App. Phys. Lett., Vol. 126, Art. No. 242107 (2025)
[3] Y. Hiranaga, and Y. Cho, Jpn. J. Appl. Phys. 64, 09SP06 (2025).

Materials Functionality Design

Computational Design of Materials and their Functionalities for Information Devices

Materials Functionality Design: Masafumi Shirai, Professor
Materials Science under Extreme Conditions: Kazutaka Abe, Associate Professor

[Research Target and Activities]

Our research targets are as follows: (1) theoretical analyses of quantum phenomena in materials for advanced information devices, (2) computational design of new materials possessing novel functionalities for improvement of device performance, and (3) development of new design procedures based on large-scale computational simulation and data-driven approaches. Our research activities in FY 2025 are as follows:

(1) Theoretical design of new materials for spintronic applications

We investigated the structural, magnetic, and magneto-transport properties of new magnetic materials. We confirmed that quaternary Heusler alloys CoRuTiSn and CoRuTiGe possess an electronic structure typical for spin-gapless semiconductors [1,2]. We also elucidated that the perpendicular magnetic anisotropy of metastable bcc Co-Mn-Fe alloys can be attributed to the tetragonal strain due to lattice mismatch with MgO [3].

(2) Analysis of anharmonic lattice dynamics in metallic hydrides

We have developed a simple way to perform the stochastic self-consistent harmonic approximation in which stochastic sampling is carried out by using effective interatomic potential. The method is applied to metallic SH_3 and shows that the Im-3m phase of SH_3 is dynamically stabilized only with anharmonic effects. The results agree with previous analyses in which stochastic sampling is done directly by *ab initio* calculations requiring large-scale computations.

[Staff]

Professor: Masafumi Shirai, Dr.
Associate Professor: Kazutaka Abe, Dr.
Assistant Professor: Masahito Tsujikawa, Dr.
Assistant Professor: Tufan Roy, Dr.

[Profile]

Masafumi Shirai received the Doctor of Engineering degree from Osaka University in 1989. Since 2002, he has been a Professor at Tohoku University.
Kazutaka Abe received Doctor of Science degree from Osaka University in 1998. Since 2003, he has been at Tohoku University as a Research Associate and currently as an Associate Professor.

[Papers]

[1] R. Kumar, T. Roy, M. Shirai, and S. Gupta, "Low-moment semiconducting properties of quaternary Heusler alloy CoRuTiSn," J. Alloy Compd., Vol.1026, pp. 180530/1-7, 2025
[2] R. Kumar, T. Roy, B. Ghadai, R. Kumar, S. Mondal, A. Kumar, A. Lakhani, D. Kumar, M. Shirai, and S. Gupta, "CoRuTiGe: A possible spin gapless semiconductor," Phys. Rev. Mater., Vol. 10, pp. 034413/1-11, 2026
[3] T. Roy, S. Kubota, M. Tsujikawa, and M. Shirai, "Understanding of electronic structure and magnetism of body-centered cubic Co-Mn-Fe alloys for magnetic tunnel junctions," Phys. Rev. Mater., Vol. 9, pp. 114406/1-7, 2025

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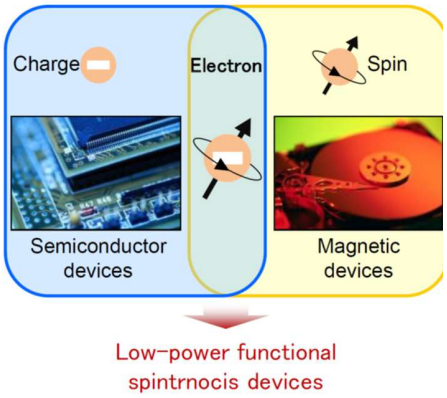
Spintronics

Advanced technology for spintronics-based devices

Functional Nano-Spintronics: Shunsuke Fukami, Professor
Functional Nano-Spin Devices: Shun Kanai, Associate Professor

[Research Target and Activities]

We aim to deepen the understanding of spin-related physics and to develop new functional materials and devices in which electron and its spin states are controlled. We are also working on research and development of advanced technology for spintronics-based devices and unconventional computing, which offer high-performance and low-power information and communication tecnologies.



The outcomes in the last fiscal year include (1) discovery of fundamental difference between magnetic octupole and dipole in their response to spin torque, (2) establishment of basic understanding to tailor single-nanometer magnetic tunnel junction for various MRAM applications, and (3) proposal and demonstration of energy-efficient and easy-to-manufacture probabilistic computer with CMOS and stochastic nanomagnet.

[Staff]

Professor: Shunsuke Fukami, Ph.D.
Associate Professor: Shun Kanai, Ph.D.

[Profile]

Shunsuke Fukami received Ph.D. degree from Nagoya University in 2012. He joined NEC Corp (2005). He moved to Tohoku University (2011). He received the JSAP Paper Award (2012), the Funai Research Incentive Award (2014), the JSAP Young Scientist Presentation Award (2014), the Young Scientists' Prize of Science and Technology by the MEXT (2015), Aoba Foundation Award (2017), Asian Union of Magnetics Societies, Young Researchers Award (2018), the Outstanding Research Award of the Magnetics Society of Japan (2018), the JSAP Outstanding Paper Award (2019), Marubun Research Encouragement Award (2021), InaRIS Research Fellow (2022), Achievement Award of the Magnetic Society of Japan, JSPS Prize (2023), and KDDI Foundation Award (2025).

Shun Kanai received Ph.D. degree from Tohoku University in 2014 and joined Tohoku University (2014). He received the Tohoku University President's Award (2010), JSAP Young Scientist Presentation Award (2014), Young Scientist Award of Aoba Foundation (2015), Young Scientist Award of Funai Foundation (2016), Harada Young Research Award (2016), Young Scientist Award of Inoue Research Foundation (2017), Hiroshi Ando Memorial Award (2017), Young Scientists' Prize of Science and Technology by the MEXT (2023), Young Scientists' Award of Honda Memorial Foundation(2023), Funai Academic Award (2025), Aoba Foundation Award (2025), JSPS Paper Award (2026).

[Papers]

[1] Y. Takeuchi, Y. Sato, Y. Yamane, J.-Y. Yoon, Y. Kanno, T. Uchimura, K. V. De Zoysa, J. Han, S. Kanai, J. Ieda, H. Ohno, and S. Fukami, "Electrical coherent driving of chiral antiferromagnet," Science 389, 830-834 (2025). doi:10.1126/science.ado1611

[2] K. Selcuk, N. A. Aadit, C. Delacour, J. Q. Silva, N. S. Singh, H. Kaneko, S. Kanai, Y.-J. Wu, Y.-H. Chen, Y.-S. Chen, Y. C. Ong, K.-C. Huang, H. Chuang, H. Ohno, S. Fukami, and K. Y. Camsari, "DAC-Free p-bits: Asynchronous Self-Coloring and On-Chip Annealing," 2025 IEEE International Electron Devices Meeting (IEDM) , (2026). doi:10.1109/IEDM50572.2025.11353558

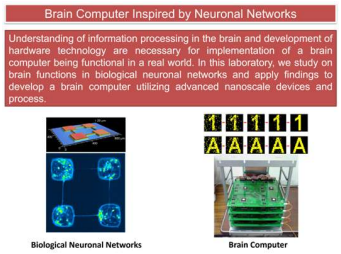
Nano-Integration Devices and Systems

Deepening of nano-integration technology and development of brain computer

Nano-Integration Devices — Shigeo Sato, Professor
Group IV Quantum Heterointegration — Masao Sakuraba, Associate Professor
Nano-Integration Neurocomputing Systems — Hideaki Yamamoto, Associate Professor

[Research Target and Activities]

In this laboratory, we focus on non-von Neumann computing, such as brain computing and quantum computing, and study their hardware technology. We conduct research on various topics including device, process, circuit, algorithm, and neuroscience, and build revolutionary new computer technology by integrating our findings. In this year, following results have been obtained: (1) We integrated the analog circuit block with an energy-harvesting circuit in a reservoir computing system based on an extremely low-power SNN (spiking neural network), and demonstrated that the reservoir layer can operate solely on harvested energy. In addition, toward scaling up the SNN, we successfully designed an inter-neuron spike-routing circuit that enables multi-chip operation. (2) We found that introducing a B atomic layer of 0.12 or more atomic layers into the 4H-SiC MOS interface significantly expands the hysteresis of the C-V curve of an Al gate MOS diode. Furthermore, we fabricated a pn diode using highly doped Si deposited by ECR plasma CVD and successfully created an Esaki diode that exhibits negative differential resistance at an appropriate undoped Si layer thickness. (3) We demonstrated a novel application of cultured neuronal networks in physical reservoir computing. By applying FORCE learning to the activity of rat cortical neurons, we showed that the system can autonomously generate various temporal signals.



Towards the Realization of a Brain Computer

[Staff]

Professor: Shigeo Sato, Dr.
Associate Professor: Masao Sakuraba, Dr.
Associate Professor: Hideaki Yamamoto, Dr.
Specially Appointed Assistant Professor: Satoshi Moriya, Dr.

[Profile]

Shigeo Sato received his B.E. and Ph.D. degrees from Tohoku University, in 1989 and 1994, respectively. In 1996, he joined the Research Institute of Electrical Communication, Tohoku University. Now, he studies brain computer and quantum computer as a professor.

Masao Sakuraba received his B.E. and Ph.D. degrees from Tohoku University in 1990 and 1995, respectively. In 1995, he joined the Research Institute of Electrical Communication, Tohoku University. Now, he studies group IV quantum heterointegration as an associate professor.

Hideaki Yamamoto received his B.E. and Ph.D. degrees from Waseda University in 2005 and 2009, respectively. In 2020, he joined the Research Institute of Electrical Communication, Tohoku University. Now, he studies neuronal network functions as an associate professor.

[Papers]

[1] H. Nagasawa, M. Abe, T. Tanno, M. Musya, M. Sakuraba, S. Sato, Y. Watanabe and M. Suemitsu, Formation of Alternating Epilayers of 4H-SiC and 3C-SiC by Simultaneous Lateral Epitaxy", Materials Science Forum, vol. 1157, pp. 33-41, 2025.

[2] Y. Sono, H. Yamamoto, Y. Nishi, T. Sumi, Y. Sato, A. Hirano-Iwata, Y. Katori, S. Sato, "Online supervised learning of temporal patterns in biological neural networks under feedback control," Proc. Natl. Acad. Sci. U.S.A., vol. 123, e2521560123, 2026.

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Quantum Devices

Electronic properties of nanostructures and device applications

Quantum Devices: Tomohiro Otsuka, Associate Professor

[Research Target and Activities]

In solid-state nanostructures, exotic phenomena like quantum effects occur. We are exploring interesting properties of solid-state nanostructures utilizing precise and high-speed electrical measurement and control techniques. We are also developing materials and devices using nanostructures.

Our research activities in FY 2025 are as follows.

(1) Development of local measurement and control techniques

We developed electronic measurement and control methods for local electronic states in nanostructures utilizing semiconductor quantum dots. We improved measurement and control techniques using cryogenic devices, high-speed circuits, and novel materials.

(2) Measurement of local electronic states in nanostructures

We measured local electronic and spin states in nanostructures using sensitive electronic measurement techniques. We investigated electronic transport phenomena in semiconductor quantum dots and novel nanostructures [2].

(3) Development of quantum devices and systems

We studied semiconductor quantum devices and systems for quantum information processing. We investigated the measurement and control of quantum states, and developed scalable quantum-device technologies and devices based on novel materials [1, 3].

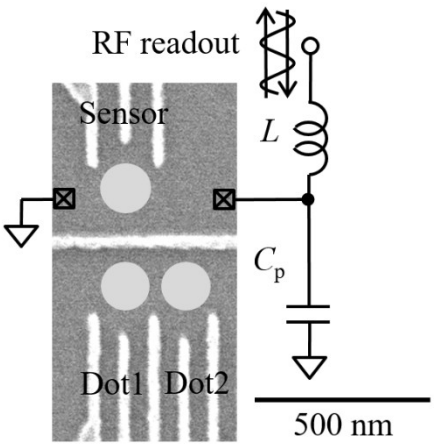


Figure: Scanning electron micrograph of a nanostructure device

[Staff]

Associate Professor: Tomohiro Otsuka, Ph.D.

[Profile]

Tomohiro Otsuka received Ph.D. degree from the University of Tokyo in 2010. After working for the University of Tokyo and RIKEN, he became an Associate Professor at Tohoku University in 2018. He received Research Encouraging Prize from School of Science, University of Tokyo (2010), Young Scientist Award of the Physical Society of Japan (2017), RIKEN Researcher Incentive Award (2017), Yazaki Memorial Foundation for Science and Technology Research Encouraging Award (2018), and the Young Scientists' Prize of Science and Technology by MEXT (2018), Distinguished Researcher in Tohoku University (2020, 2023).

[Papers]

[1] "Automatic detection of single-electron regime of quantum dots and definition of virtual gates using U-Net and clustering", Y. Muto, M. R. Zielewski, M. Shinozaki, K. Noro, and T. Otsuka, Scientific Reports 16, 8161 (2026).

[2] "Magnetotransport and Coulomb Blockade in Single InAs Colloidal Quantum Dot Transistors", K. Shibata, T. Takiguchi, A. Sato, Y. Sasaki, and T. Otsuka, ACS Nano 20, 2082 (2026).

[3] "Formation of few-electron triple quantum dots in ZnO heterostructures", K. Baba, K. Noro, Y. Kozuka, T. Kumasaka, M. Shinozaki, M. Kawasaki, and T. Otsuka, Scientific Reports 15, 36612 (2025).

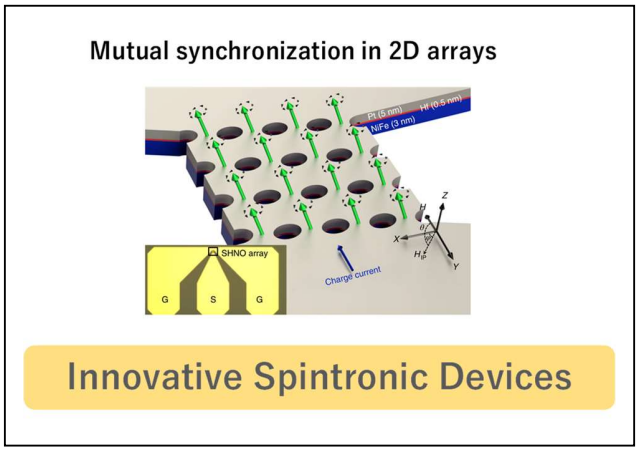
Innovative Spintronic Device

Magnetization dynamics-based innovative spintronic devices

Computing System Platforms Division: Johan Åkerman, Professor,
University Research Lead The Center for Science and Innovation in Spintronics (CSIS):
Ahmad Awad, Associate Professor

[Research Target and Activities]

In spintronic devices, the interaction between magnetization and current via electron spins is being investigated to apply it to unconventional computing such as neuromorphic computing and Ising machines. We are working on the oscillation of magnetization to DC input via the spin Hall effect and the associated output of RF signals, the realization of spin Hall nano-oscillators using magnetic resonance to RF input and the associated output of DC signals for higher performance and novel functionality, the formation of unexplored antiferromagnetic topological spin structures and their fast and efficient current-driven dynamics, etc.



[Staff]

Professor: Johan Åkerman

Associate Professor: Ahmad Awad（CSIS）

Assistant Professor: Takaaki Dohi

[Profile]

Johan Åkerman received the Ing. Phys. Dipl. degree from EPFL, Zurich, Switzerland, in 1994, the M.Sc. degree in physics from Lund University, Lund, Sweden, in 1996, and the Ph.D. degree in materials physics from KTH Royal Institute of Technology, Stockholm, Sweden, in 2000. In 2008, he was appointed Full Professor at the University of Gothenburg, Gothenburg, Sweden, and is a Guest Professor at the KTH Royal Institute of Technology. Also, he was appointed to a post at Tohoku University and - following an extensive nomination and review process - been named its first "Professor, University Research Lead" as of January 1, 2023. He is also the Founder of NanOsc AB and NanOsc Instruments AB, Kista, Sweden.

Ahmad A. Awad (Member, IEEE) received the Ph.D. degree in physics on high-frequency magnetization and vortex dynamics in both magnetic and superconducting nanostructures from the Autonomous University of Madrid, Madrid, Spain, in 2012., Since 2014, he has been a Postdoctoral Research Fellow at the University of Gothenburg, Gothenburg, Sweden. His research interests include the characterization of magnetic nanostructures and spintronic devices with a focus on spin-torque-induced magnetization dynamics. In 2023, he was appointed associate Professor at Tohoku University.

[Papers]

[1] Akash Kumar, Avinash Kumar Chaurasiya, Victor H. González, Nilamani Behera, Ademir Alemán, Roman Khymyn, Ahmad A. Awad & Johan Åkerman, "Spin-wave-mediated mutual synchronization and phase tuning in spin Hall nano-oscillators," Nature Physics **21**, 245–252 (2025). https://doi.org/10.1038/s41567-024-02728-1

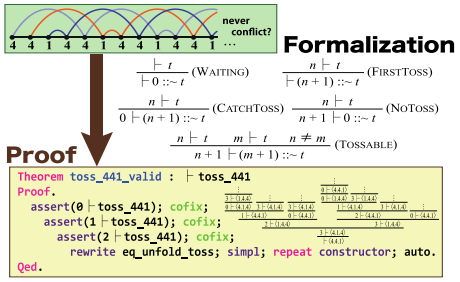
[2] T. Dohi *et al*., “Observation of a non-reciprocal skyrmion Hall effect of hybrid chiral skyrmion tubes in synthetic antiferromagnetic multilayers,” Nature Communications **16**, 8285 (2025).

Computing Information Theory

Filling the Gap between Humans and Computers

Computing Information Theory
Keisuke Nakano, Professor

[Research Target and Activities]



Notwithstanding that programming is one of the most typical methods for a human to communicate with a computer, there is a significant gap between programs that are recognizable for humans and those that are efficiently executed by computers. Programs described as humans think are highly readable but are not always efficient. On the other hand, programs described with carefully considering the behavior of computers show much better performance in time and space but are very complicated and hardly maintainable. Our ultimate goal is to fill the gap between humans and computers in programming.

More specifically, our research topics include *program transformation* and *program verification*. Program transformation is to automatically derive well-tuned and efficient programs from human-readable ones; Program verification is to statically (that is, without running) check if human-written but well-tuned complicated programs behave as the programmers expect for any input. To this end, we deeply study the theory of formal tree languages, such as tree automata and tree transducers, which has a close relationship with the program transformation and verification. Besides that, we are working on formalizing relevant results in mathematics and theoretical computer science on a proof assistant to make our theory more robust.

[Staff]

Professor : Keisuke Nakano, Dr.
Assistant Professor : Kazuyuki Asada, Dr.
Assistant Professor : Kentaro Kikuchi, Dr.

[Profile]

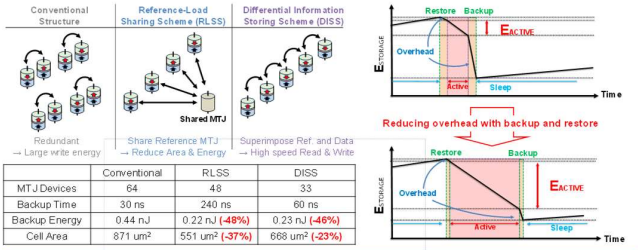
Keisuke Nakano received his Ph.D. from Kyoto University in 2006. He worked as a researcher atthe University of Tokyo from 2003 to 2008. He has been an assistant professor from 2008 to 2012 and an associate professor from 2012 to 2018 at the University of Electro-Communications. Since 2018, he has been a professor at the Research Institute of Electrical Communication. His research interests include formal language theory, programming language theory, and functional programming. He is a member of ACM, JSSST, and IPSJ.

[Papers]

[1] Munehiro Iwami and Keisuke Nakano, "Disproving Termination of O and S-like Combinators by Tree Automata", Journal of Information Processing Vol.34 39-44 (Jan. 2026).
[2] Kosuke Onodera, Keisuke Nakano, Kazuyuki Asada, and Kentaro Kikuchi, "IsoLang: a User-Friendly Reversible Programming Language with Inductive Types", The 28th Workshop of Programming ang Programming Languages (PPL 2026).
[3] Yo Ito and Kazuyuki Asada, “Reconstruction of Σ-module models via completion and tight orthogonality,” Workshop on Computer Science and Category Theory (CSCAT 2026), 2026.
[4] Takumu Nakamura, Kazuyuki Asada, and Keisuke Nakano, “Analysis of the Mathematical Structures of Learning Algorithms,” The 28th Information-based Induction Sciences Workshop (IBIS 2025), 2025.

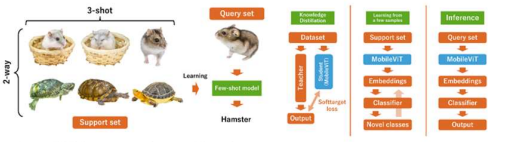
New Paradigm VLSI System Research Group

Realization of a New-Paradigm VLSI-Computing World



	Conventional	RLSS	DISS
MTJ Devices	64	48	33
Backup Time	30 ns	240 ns	60 ns
Backup Energy	0.44 nJ	0.22 nJ (-48%)	0.23 nJ (-46%)
Cell Area	871 um²	551 um² (-37%)	668 um² (-23%)

Energy/Area-Aware MTJ-Based Nonvolatile Register for Intermittent Computing

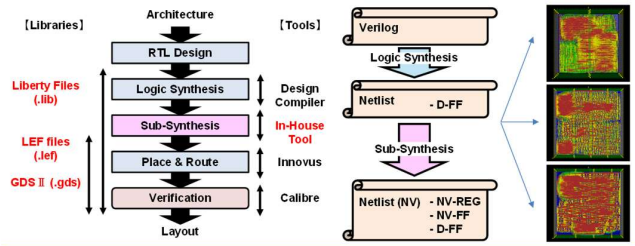


Method	1-shot	5-shot
EASY + ResNet12	70.84±0.19	86.28±0.12
EASY + MobileViT-XXS (ours)	75.08±0.10	88.43±0.08
EASY + KD + MobileViT-XXS (ours)	**85.08±0.06**	**92.96±0.05**

Metric	Idle	ResNet	MobileViT-XXS
Power (W)	4.0	19.9	14.0
Latency (ms)	–	3.6	2.6
Throughput (ips)	–	280	392
Energy/inf (J)	–	0.072	0.036

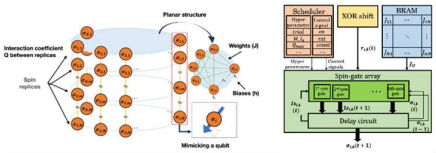
Efficient Few-Shot Learning for Edge AI

S. Tsuyuki, et al., ICASSP 2026.



Automated Design Flow for Large-Scale Nonvolatile-Logic Circuits

T. Yoshida, et. al., IEEE ISCAS, 2025 / M. Natsui, et al., IEEE JXCDC, 2025.



	Proposed	HA-SSA [15]	IPAPT [25]
Hardware architecture	Spin serial	Spin parallel	Spin parallel
Graph support	Fully connected	Limited to 4 neighbors	Limited to 4 neighbors
Number of connections per spin	up to 799	4	4
Bit width of h and J supported	4	4	2
Energy	1.093 mJ	2.138 mJ	N/A
Mean cut value	558.4	558	561

Energy-Efficient Quantum-Inspired Annealing Hardware

N. Onizawa, et al., IEEE Access 2026.

New Paradigm VLSI System : Takahiro Hanyu, Professor
New Paradigm VLSI Design : Masanori Natsui, Associate Professor
New Paradigm VLSI Computing : Naoya Onizawa, Associate Professor

[Research Target and Activities]

Performance degradation of SoCs due to wiring complexity, power dissipation and device-characteristic variation are increasingly getting serious problems in the recent Very Large Scale Integration (VLSI) chip. Our research activity is to solve the problems primarily by the following two ways: the logic-in-memory architecture based on nonvolatile logic, and the brainware LSI (BLSI) computing, which would open up a novel VLSI chip paradigm, called a "new-paradigm VLSI system." This year, we have succeeded in some research activities that are demonstrated in the above figures.

[Staff]

Professor : Takahiro Hanyu, Dr. Associate Professor : Masanori Natsui, Dr.
Associate Professor : Naoya Onizawa, Dr.

[Profile]

Takahiro Hanyu received the Ph.D. degree in electronic engineering from Tohoku University, Sendai, Japan, in 1989. His general research interests include new paradigm logic circuits and their application to high performance and ultra-low-power edge AI VLSIs.

Masanori Natsui received the Ph.D. degrees in information Sciences from Tohoku University, Sendai, Japan, in 2005. His research interest includes automated circuit design technique, nonvolatile-based circuit architecture and its application, and design of high-speed low-power integrated circuits.

Naoya Onizawa received the Ph.D. degree in electronic engineering from Tohoku University, Sendai, Japan, in 2009. His general research interests include new paradigm logic circuits and their application to high performance and ultra-low-power edge AI VLSIs.

[Papers]

[1] T. Yoshida, M. Natsui, and T. Hanyu, "Design of a Low-Energy MTJ-Based Nonvolatile Register Based on a Differential Information Storing Scheme," 2025 IEEE International Symposium on Circuits and Systems (ISCAS2025) May 2025. DOI: 10.1109/ISCAS56072.2025.11043267

[2] M. Natsui, T. Yoshida, and T. Hanyu, "Reference-Load Sharing Scheme: An Area- and Energy-Efficient Nonvolatile Register Design Using MTJ Devices," IEEE Journal on Exploratory Solid-State Computational Devices and Circuits, Vol.11, pp.90-98, 2025. DOI: 10.1109/JXCDC.2025.3611365

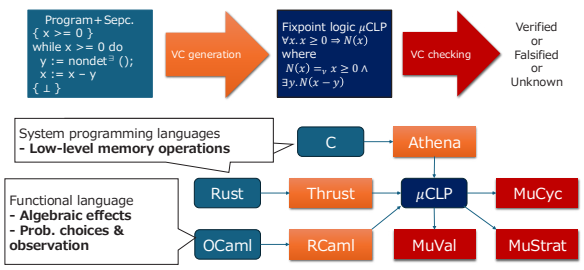
[3] S. Tsuyuki, R. Bensaid, J. Morlier, M. Leonardon, N. Onizawa, V. Gripon, and T. Hanyu, "EFFICIENT FEW-SHOT LEARNING FOR EDGE AIVIA KNOWLEDGE DISTILLATION ON MOBILEVIT," *Proc. 51st IEEE International Conference on Acoustic, Speech, and Signal Processing (ICASSP)*, pp. May. 2026 (to appear)

Software Construction

Logical Approach to Reliable and Efficient Next-Generation Software

Software Construction, Hiroshi Unno, Professor

[Research Target and Activities]



In modern society, people regularly use smartphones and computers in their personal lives and work, and unnoticed, computer-controlled infrastructure such as transportation, finance, healthcare, and energy plays a crucial role. Therefore, ensuring the reliability of software that controls computers and improving its efficiency are important challenges for maintaining social stability and smooth functioning. In our laboratory, we research techniques to construct highly reliable and efficient software, based on foundational theories like formal logic and program theory. In particular, we conduct research and development on program verification, which mathematically guarantees that a given program satisfies its specification, and program synthesis, which automatically generates programs from specifications. For example, we are developing RCaml, Thrust, and Athena, which aim to promote the development of highly reliable and efficient software by integrating verification and synthesis tools into various programming languages such as OCaml, Rust, and C. We are also developing PCSat, MuVal, MuCyc, and MuStrat, which are solvers capable of expressing and solving a wide range of verification and synthesis problems as predicate constraints or fixpoint logic formulas. In addition, we study the underlying foundations of these tools, including program theory and type theory, theories of constraint solving and optimization, and fixpoint logics and their proof systems.

[Staff]

Professor : Hiroshi Unno, Dr.
Assistant Professor : Clovis Eberhart, Dr

[Profile]

Hiroshi Unno is a Professor at the Research Institute of Electrical Communication, Tohoku University, Japan. He received his Ph.D. in Information Science and Technology from the University of Tokyo in March 2009, and then worked as a postdoctoral researcher at Tohoku University and the University of Tokyo. In July 2012, he joined University of Tsukuba as an Assistant Professor in the Faculty of Engineering, Information and Systems, was promoted to Associate Professor in April 2017, and moved to his current position in April 2024.

[Papers]

[1] Taro Sekiyama, Ugo Dal Lago, and Hiroshi Unno. On Higher-Order Model Checking of Effectful Answer-Type-Polymorphic Programs, Proc. ACM on Programming Languages, Volume 9, Issue OOPSLA2, ACM, Article No. 406, pp.3726-3754, October, 2025.

[2] Hiromi Ogawa, Taro Sekiyama, and Hiroshi Unno. Thrust: A Prophecy-based Refinement Type System for Rust, Proc. ACM on Programming Languages, Volume 9, Issue PLDI, ACM, Article No. 230, pp.2056-2080, June, 2025.

[3] Sasinee Pruekprasert and Clovis Eberhart, AP-Observation Automata for Abstraction-Based Verification of Continuous-Time Systems, Proc. ICTAC 2025, LNCS 16237, pp.338-356, November, 2025.

Quantum Nanoelectronics Laboratory

Development of a New Magnetic Materials for the Efficient Operation of Spintronic Devices

Quantum Nanoelectronics Atsufumi Hirohata, Professor

[Research Target and Activities]

1. Evaluation of the motion of magnetic skyrmions

A magnetic skyrmion is known to possess almost three orders of magnitude smaller diameter than the width of a magnetic domain wall and approximately five orders of smaller critical current density than that for a domain wall. Accordingly skyrmions have been attracting much interest in their applications for memory and logic devices. However an interfacial defect can scatter them randomly during their motion, which prevents their applications. We have assessed our recently- developed current-induce interfacial smoothing to create a potential to confine a skyrmion.

2. Demonstration of a spin-polarised field effect transitor

In a conventional field effect transistor, the flow of electrons can be controlled by applying a gate bias voltage, resulting in switch operation. Under the recent obstacle to fabricate a post-Moore transistor, a spin-polarised electron can be used for higher density operation but the corresponding gate length has been reported to be over 1 micron. We have hence been designing a new spin transistor to shorten the gate length comparable to the current conventional transistor.

3. Measurement of a surface plasmon polariton

A surface plasmon polariton can be easily generated at an interface between a metal and oxide by introducing a linearly-polarised laser light, which can be detected by the inverse spin Hall effect. Such a phenomenon can be ideal to connect spintronic operation and optical communication. We have been optimising the conditions to generate a polariton at a series of metal/oxide interfaces.

[Staff]

Professor : Atsufumi Hirohata, PhD
Specially appointed assistant professor : A Young Lee, PhD
Post-doctoral researcher : Misbah Yaqoob, PhD

[Profile]

Atsufumi Hirohata obtained his BSc and MSc from the Department of Physics at Keio University in 1995 and 1997, respectively. He then received his PhD from the University of Cambridge in 2001. After serving as a post-doctoral researcher at the Cavendish laboratory, he moved to the Massachusetts Institute of Technology in 2002. He then served as a CREST researcher at Tohoku University in 2003, followed by a researcher at RIKEN in 2005. He secured a lectureship at the University of York in 2007 and promoted to a reader, professor and senior professor in 2011, 14 and 18, respectively. Since October 2023, he is a professor at Tohoku University. He has been working on the development of a new magnetic materials, including Heusler alloys, and their spintronic device applications.

[Papers]

[1] A. Hirohata *et al.*, "Characteristic frequencies in magnetic and spintronic phenomena," Newton Vol. 1, No. 7, pp. 100192, 2025.
[2] A. Hirohata *et al.*, "Machine learning for the development of new materials for a magnetic tunnel junction," npj Spintron. Vol. 3, pp. 32, 2025.
[3] K.-F. Huang *et al.*, "Magnetics for Future Transportation - from Memory to Motors," IEEE Magn. Lett. Vol. 16, pp. 2100205, 2025.

Contact to Professor HIROHATA Atsufumi : atsufumi.hirohata.d1@tohoku.ac.jp

Information Communication Platforms Division: Research Targets and Results

This division aims to research and develop ultra-high-speed, high-performance, ultra-low-power optical/high-frequency devices and secure, resilient, and green broadband ICT infrastructure to create next-generation information communication systems that support a sustainable smart society. The following is an overview of the research activities of the core laboratories in this academic year.

(1) Ultrahigh-Speed Optical Communication

We are engaged in research on ultrahigh-speed optical transmission, digital coherent transmission, and high-speed and spectrally efficient optical transmission by combining these two approaches. With a view to supporting innovative new ICT services such as 5G and IoT, our goal is also to develop novel transmission schemes integrating optical and wireless communications. This year, we demonstrated a polarization division multiplexed (PDM) fully coherent optical and wireless transmission system using a polarization-independent injection locking circuit. 216 Gbit/s PDM-64 QAM signals were successfully transmitted over a 10 km optical fiber and a 10 m wireless link.

(2) Applied Quantum Optics

Novel functional semiconductor photonic devices including photonic integrated circuits and laser sources are being investigated to explore next-generation photonic network systems and photonic measurement system.

We achieved phase fluctuation compensation within a 50-km two-core fiber using a narrow-linewidth CW laser phase-locked to a high-Q Fabry-Pérot resonator. This establishes a foundation for advanced Quantum Key Distribution (QKD) utilizing two-core fibers.

(3) Advanced Wireless Information Technology

We are actively engaged in research work on wireless Internet of Things (IoT) technologies for next-generation wireless systems, which include terrestrial / satellite communications. The covered areas of us are all technical fields from the lower to higher layers, i.e., digital signal processing, RF/Mixed-signal device, antenna, transceiver, and subsystem technologies. This year, we have developed a 4-element digital beam forming (DBF) antenna module as a partial prototype of 40GHz-band on-board DBF array antenna for next generation low earth orbit (LEO) constellation satellites and successfully demonstrated its multi-beam formation using DBF function

(4) Information Storage Systems

Research on next-generation perpendicular magnetic recording is being carried out to meet the strong demand for high-density, high-performance storage due to the rapid growth of the internet, web services, and AI. Research into magnetic devices for neuromorphic applications is also ongoing.

We have been investigating novel, three-dimensional, energy-assisted recording technologies that have the potential to double the density of information stored on hard disk drives. This year, our research concentrated on heat-assisted magnetic recording (HAMR), focussing on both recording and signal processing. We have also been studying arrays of stochastic magnetic tunnel junctions for use as logic gates, factorisation, etc.

(5) Ultra-Broadband Signal Processing

We are developing novel, integrated electron devices and circuit systems operating in the terahertz (THz) region utilizing compound semiconductor heterostructure and graphene- based 2D materials.

First, regarding the THz plasmonic detector based on an InGaAs HEMT, we succeeded in enhancing the detector internal responsivity by introducing an electrode structure that suppresses the rise of the channel potential. Second, we fabricated a UTC-PD-integrated grating-gate HEMT and demonstrated the heterodyne detection operation at the 300-GHz band using it. Third, we conducted theoretical study, fabrication, and evaluation of THz detectors based on low-dimensional-material heterostructures and demonstrated high-speed THz detection with a response time on the order of 200 ps under zero bias.

(6) Quantum Optical Information and Communication Engineering

Toward the realization of an advanced information society represented by Society 5.0, we are promoting research on photonic quantum computers and next-generation optical communication devices that support ultrafast, high-capacity, and low-latency information processing and communication infrastructures. In particular, we conduct research on photonic quantum control and optical device technologies for quantum information processing,

Using silicon photonics, we realized a low-noise and highly stable squeezed-vacuum optical source. Furthermore, we constructed an analog photonic quantum computer integrated and successfully applied it to quantum chemistry calculations as a practical application problem. We also demonstrated low-crosstalk localized optical propagation in densely integrated silicon waveguide optical interconnects with half-wavelength pitch spacing. In addition, we demonstrated a novel method for quantum tomography of photonic quantum states that can be implemented using only beam splitters.

(7) Network Architecture

We have promoted research on information network systems and their applications that support diverse human activities. (1) Implementation and evaluation of a node that performs in-network congestion control, fundamentally redefining conventional approaches. (2) Development of a new algorithm that significantly reduces throughput unfairness caused by communication distance on the Internet. (3) Promotion of research and development of traffic compression technologies for log collection and analysis in wide-area networks. (4) Development of machine learning–based algorithms to improve the efficiency of 5G network resource utilization through the use of edge computing. (5) Experimental evaluation of adaptive configuration methods of microservice-based network applications.

(8) Environmentally Conscious Secure Information System

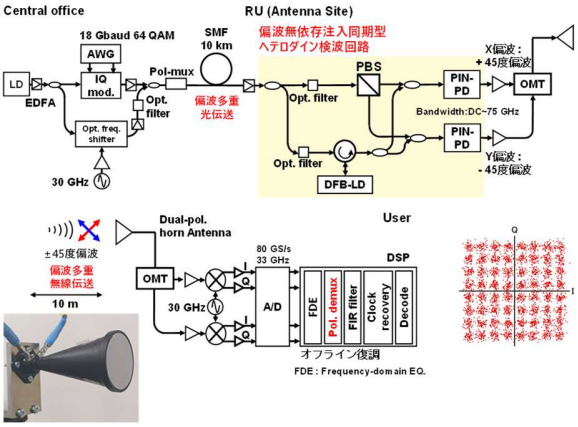
We are conducting research and development on the theories and implementation technologies of secure information communication systems. This year, we successfully developed a new method to add authenticated encryption functionality to the XTS mode, a standard for storage encryption, enabling data tampering detection. We also revealed the threat of a new machine-learning-based side-channel attack, XCCA (XOR superimposed collision analysis), against cryptographic hardware. Furthermore, we developed a non-invasive method for detecting aged, illegally reused equipment from leaked electromagnetic waves.

Research Laboratory of Ultrahigh-Speed Optical Communication

Toward Innovative Optical Transmission from Backbone to Access Network

Research Area of Ultrahigh-Speed Optical Transmission Toshihiko Hirooka, Professor
Research Area of Lightwave Control System Keisuke Kasai, Associate Professor

[Research Target and Activities]



Advanced global ICT services such as ultrahigh-definition video transmission and ultra-realistic communication cannot be realized without high-speed and large-capacity optical transmission systems. At the same time, optical transmission schemes with high spectral efficiency are crucial in terms of the maximum utilization of limited bandwidth resources. In our laboratory, we are engaged in research on ultrahigh-speed optical transmission using optical time division multiplexing with a single-channel Tbit/s-class capacity, digital coherent QAM optical transmission, and high-speed and spectrally efficient optical transmission by combining these two approaches. With a view to supporting innovative new ICT services such as 5G and IoT, our goal is also to apply digital coherent transmission to access networks and mobile fronthaul, and to develop novel transmission schemes integrating optical and wireless communications. This year, we demonstrated a polarization division multiplexed (PDM) fully coherent optical and wireless transmission system using a polarization-independent injection locking circuit. 216 Gbit/s PDM-64 QAM signals were successfully transmitted over a 10 km optical fiber and a 10 m wireless link.

[Staff]

Professor: Toshihiko Hirooka, Dr. Associate Professor: Keisuke Kasai, Dr.

[Profile]

Toshihiko Hirooka received the Ph. D. degree from Osaka University in 2000. From 2000 to 2002, he was a Research Associate at University of Colorado at Boulder. He is currently a Professor at the Research Institute of Electrical Communication, Tohoku University. He has been engaged in research on ultrahigh-speed optical communications and nonlinear fiber optics.

Keisuke Kasai received the Ph. D. degree from Tohoku University in 2008. From 2009 to 2012, he was a JSPS Research Fellow. He is currently an Associate Professor at the Research Institute of Electrical Communication, Tohoku University. He has been engaged in research on lightwave control techniques and coherent optical communications.

[Papers]

[1] M. Nakazawa and T. Hirooka, "An Oscillator-Less Photonic Ising Machine With Digital-Nonlinearity-Based Bifurcation and Its Simulated Application to a 1 Million-Node Fully Connected Max-Cut Problem," J. Lightwave Technol., vol. 43, no. 12, pp. 5579-5600, June (2025).
[2] M. Yoshida, T. Yoshida, S. Beppu, Y. Wakayama, N. Yoshikane, K. Kasai, T. Hirooka, and M. Nakazawa, "Guided acoustic-wave Brillouin scattering noise in few-mode fiber," Opt. Express vol. 33, no. 16, pp. 34586-34603, August (2025).
[3] T. Joichi, A. Watanabe, K. Kasai, T. Hirooka, M. Yoshida, and M. Nakazawa, "108 Gbit/s, 64 QAM fully-coherent mobile-fronthaul transmission over 10 km SMF and 70 m wirelessly in the 125 GHz band," Opt. Express, vol.34, no. 4, pp. 6345-6354, February (2026).

Applied Quantum Optics

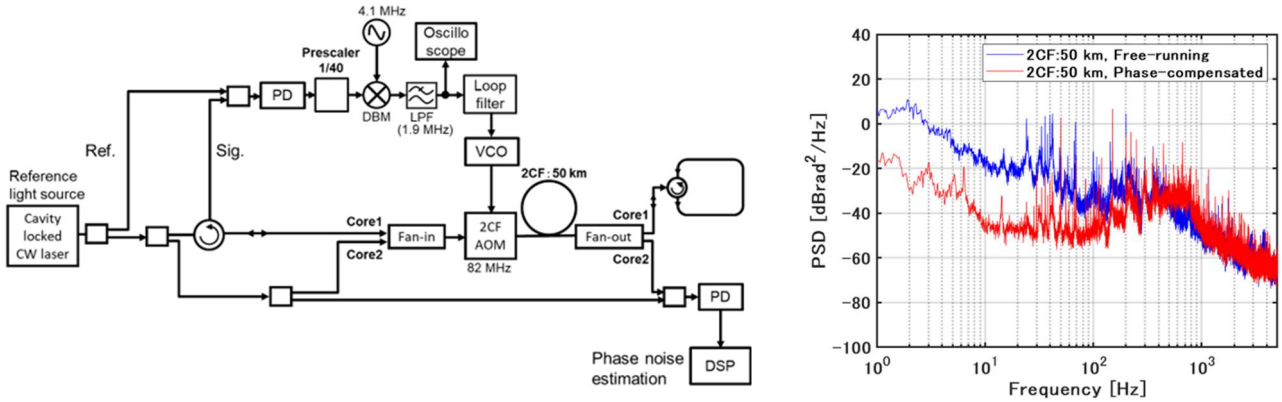
Research on Innovative Highly Functional Photonic Semiconductor Devices

High accuracy optical measurement　Masato Yoshida, Associate Professor

[Research Target and Activities]

Novel functional semiconductor photonic devices including photonic integrated circuits and laser sources are being investigated to explore next-generation photonic network systems and photonic measurement system.

We achieved phase fluctuation compensation within a 50-km two-core fiber using a narrow-linewidth CW laser phase-locked to a high-Q Fabry-Pérot resonator. This establishes a foundation for advanced Quantum Key Distribution (QKD) utilizing two-core fibers.



Experimental setup for phase noise compensation in a 50 km-long two-core fiber (left) and experimental result of phase-noise power spectral density in Core 2 (right).

[Staff]

Associate Professor：Masato Yoshida, Dr.

[Profile]

Masato Yoshida received Ph.D. degree in electronic engineering from Tohoku University in 2001. In 2001, he joined the Research Institute of Electrical Communication, Tohoku University. He is currently an Associate Professor of the Institute.

[Papers]

[1] M. Yoshida, T. Yoshida, S. Beppu, Y. Wakayama, N. Yoshikane, K. Kasai, T. Hirooka, and M. Nakazawa, "Guided acoustic-wave Brillouin scattering noise in few-mode fiber," Opt. Express vol. 33, no. 16, pp. 34586-34603, August (2025).
[2] M. Yoshida and M. Nakazawa, “Multicore Fiber for Quantum Communication,” EXAT 2025, P-3, May (2025).
[3] M. Yoshida, T. Hirooka, and M. Nakazawa, "GAWBS Noise in Digital Coherent and SDM Transmission," OECC 2025, Invited paper, WB2-1, July (2025).

Advanced Wireless Information Technology

For realization of the next generation wireless devices and systems

Advanced Wireless Information Technology Noriharu Suematsu, Professor

[Research Target and Activities]

We are actively engaged in research work on wireless Internet of Things (IoT) technologies for next generation wireless systems, which include terrestrial / satellite communications. The covered areas of us are all technical fields from the lower to higher layers, i.e., digital signal processing, RF/Mixed-signal device, antenna, transceiver, and subsystem technologies.

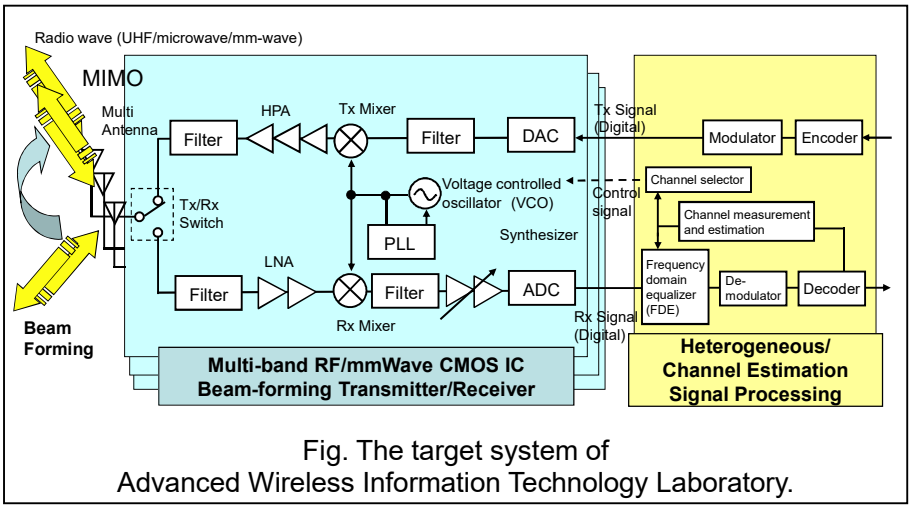


Fig. The target system of
Advanced Wireless Information Technology Laboratory.

This year, we have successfully developed millimeter-wave DBF array antenna modules which can be connected with DSPs with digital RoF using 100GbE components. These results can be used for LEO constellation satellite communication system and distributed MIMO antenna terrestrial wireless communication system. We have also revealed a 2.45GHz reftification performance of fabricated diamond SBD and have successfully demonstrated a maxium DC output power of 3 W, which is almost the same as the world's highest performance of conventional GaN SBDs..

[Staff]

Professor: Noriharu Suematsu, Ph. D
Assistant Professor: Tomoyuki Furuichi, Ph.D

[Profile]

Noriharu Suematsu received the M.S. and Ph.D. degrees in Electronics and Communication Engineering from Waseda University in 1987 and 2000. From 1987 to 2010, he had been with the R&D center of Mitsubishi Electric, Japan. Since 2010, he has been a professor of Research Institute of Electrical Communication (RIEC), Tohoku University. He received the OHM technology award from the promotion foundation for electrical science and engineering in 2002, Prize for Science and Technology, the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology in 2009, IEICE Electronics Society Award in 2012, and IEICE Achievement award in 2025. He is a fellow of IEICE.

[Papers]

[1] Junhao Zhang, Koki Furuuchi, Noriharu Suematsu, "A Prototype of 20GHz-Low-Complexity Digital Beamforming Transmitter Antenna Module for FR3 Band Using Direct Digital RF Technology in DSoF Configuration," IEEE Access, vol.14, pp.49801-49814, Mar. 2026.
[2] Koki Furuuchi, Ryosei Miyagawa, Yuki Fujiya, Junhao Zhang, Tomoyuki Furuichi, Satoshi Tsukamoto, Noriharu Suematsu, "A Compact Brick-Type 40GHz-Band DBF Transmit Antenna Module Using Direct Digital RF Technology," IEEE MTT-S IMS2025, pp.1115-1118, June 2025.
[3] Kosuke Saito, Ryunosuke Saito, Tomoyuki Furuichi, Yuji Kato, Hitoshi Umezawa, Noriharu Suematsu, "Nonlinear Modeling and Frequency Multiplication Characteristic of Quasi-Vertical Diamond SBD in L-Band," APMC2025, Dec. 2025. DOI: 10.1109/APMC65046.2025.11377606

Information Storage System Laboratory

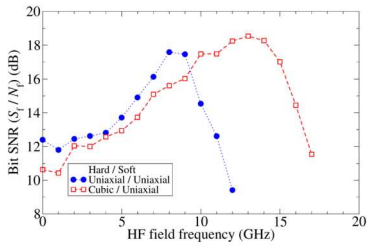
High-Density, Low-Cost Information Storage

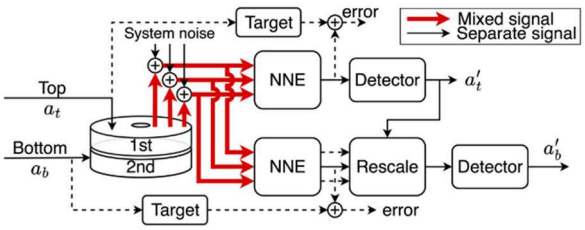
Simulation of Information Storage Devices, Simon Greaves, Associate Professor

[Research Target and Activities]

Research on next-generation perpendicular magnetic recording is being carried out to meet the strong demand for high-density, low-cost storage due to the rapid growth of the Internet and web services. We use computer simulations to study recording systems and novel technologies for data storage applications.

To increase the storage density and reduce the cost of data storage we are investigating three-dimensional, energy-assisted recording technologies that enable selective recording on media with multiple, discrete recording layers [1]-[4]. In addition, we are also studying spintronic devices, such as magnetic tunnel junctions and spin torque oscillators, for use in neuromorphic computing.





Left: SNR gain from composite recording media with cubic anisotropy layer [1]

Right: Signal deconvolution using neural networks [2]

[Staff]

Associate Professor: Simon Greaves, Ph.D.

[Profile]

Simon Greaves has been at Tohoku University since 2003. He developed micromagnetic simulation software to model magnetic recording and to investigate the potential of magnetic information storage devices. He received his Ph.D. in 1993 from Salford University, UK.

[Papers]

[1] S. J. Greaves and Y. Kanai, “Cubic anisotropy media for microwave assisted magnetic recording”, AIP Advances 16, 025209-1-5, (2026).

[2] K. Luo, Y. Zhao, Z. Liu, Y. Jian, S. Greaves, J. Chen and P. Lu, “Enhancing bottom-layer detection in dual-layer 3D magnetic recording via top-layer-assisted signal rescaling”, IEEE Trans. Magn. 62(3), 3000306-1-6, (2026).

[3] N. Rueangnetr, S. J. Greaves and C. Warisarn, “Enhancing signal processing with multilayer perceptron utilization for bit-patterned magnetic recording”, IEEE Access 13, 186843-186855, (2025).

[4] Y. Nakamura, M. Nishikawa, S. J. Greaves, Y. Kanai and Y. Okamoto, “Improvement of dual-layer HAMR recording conditions using SMR”, IEEE Trans. Magn. 62(3), 3000205-1-5, (2026).

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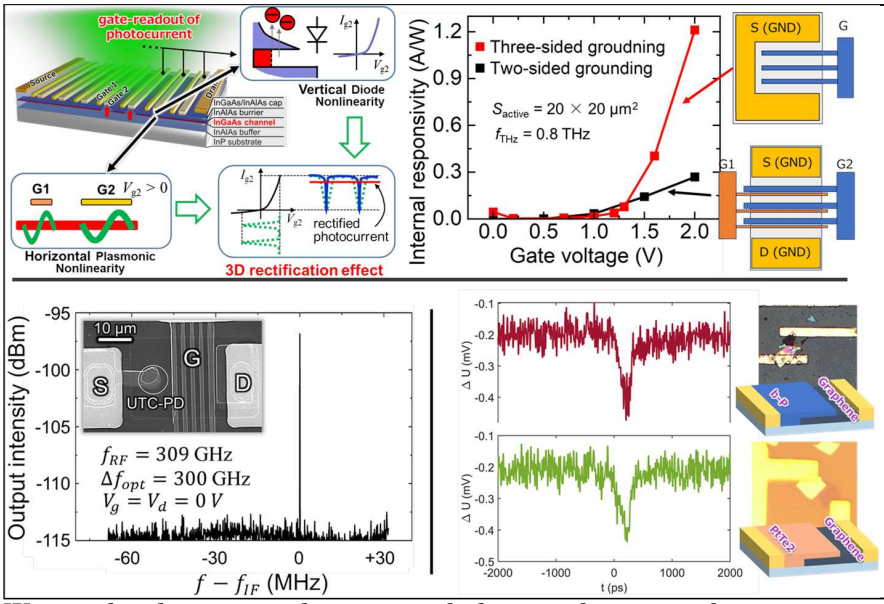
Ultra-broadband Signal Processing

Novel Millimeter-wave and Terahertz Integrated Electron Devices and Systems

Ultra-Broadband Device Physics: Akira SATOU, Associate Professor
Ultra-Broadband Quantum Electronics: Tsung-Tse LIN, Associate Professor

[Research Target and Activities]



Top: A schematic view and the operation principle of an InGaAs-channel high-electron-mobility transistor with a metallic diffraction grating structure (left) and demonstration of enhancement of the detection responsivity by introduction of a stronger channel grounding structure (right).

Bottom: Demonstration of 300-GHz heterodyne detection by a UTC-PD-integrated grating-gate high-electron-mobility transistor (left) and two-dimensional Dirac semimetal heterostructure THz detector and its demonstration of self-powered, high-speed terahertz detection (right).

We are developing novel, integrated electron devices and circuit systems operating in the millimeter-wave/terahertz (THz) region. First, we have proceeded the research of a THz detector based on InGaAs-channel high-electron mobility transistor (HEMT) utilizing the plasmonic 3D rectification effect, which is a multiplication of the plasmonic hydrodynamic nonlinearities and the diode current nonlinearity between the gate and channel. We revealed that the rise of the channel potential due to the dc current flow causes the weakening of the 3D rectification effect and succeeded in enhancing the detector internal responsivity by introducing an electrode structure that strengthens the channel grounding. Second, regarding photonics-electronics convergence devices, we fabricated an InGaAs-channel grating-gate HEMT integrated with a uni-traveling-carrier photodiode (UTC-PD) and demonstrated the heterodyne detection operation at the 300-GHz band using it. Third, we proposed a theoretical framework for THz detection based on heterostructures combining low-dimensional Dirac semimetals, such as graphene, with layered semiconductors, such as black phosphorus. Furthermore, using our laboratory's proprietary Hot Transfer technique, we fabricated low-dimensional material heterostructures and demonstrated high-speed THz detection with a response time on the order of 200 ps under zero-bias and zero-power-consumption conditions.

[Staff]

Associate Professors: Akira SATOU, Dr. Comp. Sci.
Associate Professors: Tsung-Tse LIN, Dr. Eng.
Assistant Professor: Chao TANG, Dr. Eng.
Research Fellow: Victor RYZHII, Ph.D.
Secretary: Minori KANNO

[Profile]

Akira SATOU: received Dr. Comp. Sci. from Univ. of Aizu, Japan, in 2008. He was an Assistant Lecturer, ISTC, Univ. of Aizu, in 2008 and CAIST, Univ. of Aizu, in 2009. He joined RIEC, Tohoku Univ., Japan, in 2010 as an Assistant Professor and was promoted to an Associate Professor in 2017.

Tsung-Tse LIN: received Dr. Eng. deg. from Tohoku Univ., Japan, in 2010. He was a Postdoctoral Researcher, RIKEN, in 2010 and Researcher, RIKEN, in 2016. He joined RIEC, Tohoku Univ., Japan, in 2022 as a specially appointed Associate Professor and was promoted to an Associate Professor in 2024.

[Papers]

[1] M. Nagatsu, K. Narita, Y. Takida, H. Minamide, T.-T. Lin, and A. Satou, "Grating-Gate THz Plasmonic Detector Based on an InGaAs-Channel HEMT with an InP Barrier Layer," SSDM 2025, Yokohama, Japan, Sep. 15-18, 2025. DOI: 10.7567/SSDM.2025.PS-04-18

[2] R. Takahashi, S. Horiuchi, T.-T. Lin, C. Tang, T. Otsuji, and A. Satou, "Heterodyne Detection at 300-GHz Band by a UTC-PD-Integrated HEMT Photonic Double-Mixer with a Grating-Gate Structure," SSDM 2025, Yokohama, Japan, Sep. 15-18, 2025. DOI: 10.7567/SSDM.2025.M-2-02

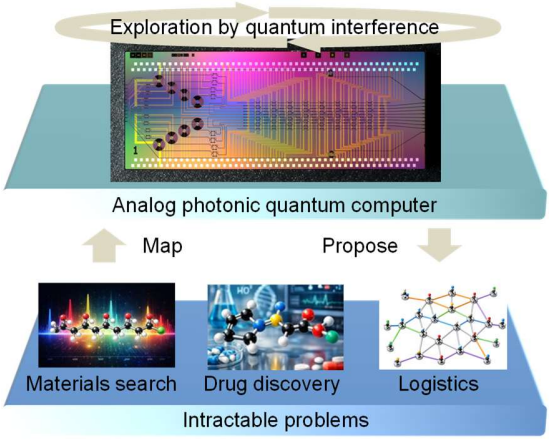
[3] K. Tamura, H. Kudo, S. Uchigasaki, C. Tang, H. Fukidome, Y. Takida, H. Minamide, A. Satou, V. Ryzhii, and T. Otsuji, "THz Detection and Coulomb Drag Instability in Epitaxial Graphene Channel Transistors," CLEO 2025, Long Beach, California, USA, May 4-9, 2025. DOI: 10.1364/CLEO_SI.2025.SS154_2

Quantum Optical Information and Communication Engineering

Next-generation information processing enabled by photonic quantum technology

Quantum Optical Information and Communication Engineering:
Nobuyuki Matsuda, Professor

[Research Target and Activities]



Toward the advanced information society represented by Society 5.0, we are promoting research on photonic quantum computing and next-generation optical communication devices that support ultra-high-speed, large-capacity, and low-latency information processing and communication infrastructures. We conduct research on photonic quantum device technologies for quantum information processing, ranging from devices, circuits to system integration.

In 2025 we achieved (1) the development of analog quantum computer using integrated photonics, (2) the high-density integration of silicon photonics waveguides, and (3) the development of a new method of optical quantum tomography.

[Staff]

Professor: Nobuyuki Matsuda, Dr. Eng.

[Profile]

Nobuyuki Matsuda received his Doctor of Engineering from the Graduate School of Engineering, Tohoku University, in 2009. From April 2009, he was a JSPS Postdoctoral Fellow, and in October 2009, he joined the University of Bristol as a Visiting Researcher. In 2010, he joined NTT Basic Research Laboratories, Nippon Telegraph and Telephone Corporation. Since September 2018, he has served as an Associate Professor at the Graduate School of Engineering, Tohoku University. He has been a Professor at RIEC, Tohoku University, since April 2025. He has been a Tohoku University Distinguished Researcher since 2022.

[Papers]

[1] M. Hifumi, S. Kimura, F. Yang, M. Okano, M. Takenaka, H. Yamada, N. Matsuda, "Generation of Single-Mode Squeezed Vacuum Using a Silicon Optical Waveguide," OECC/PSC 2025, WP-G-1, 2025.
[2] K Toyama, R. Kikuchi, H. Yamada, N. Matsuda, "Localized Light Transport in a Self-Similar Waveguide Array," OECC/PSC 2025, WP-E-5, 2025.

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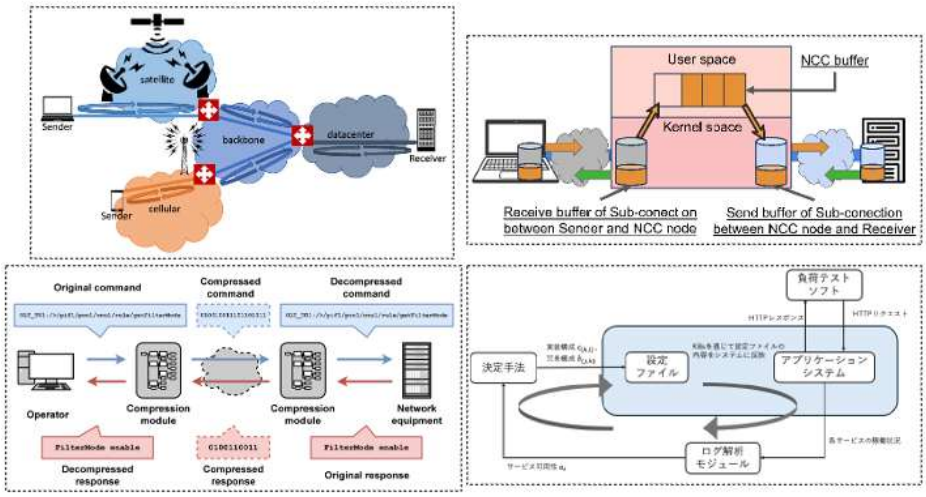
Network Architecture Lab.

Information Network Architecture for IoT/AI Era

Information Network Architecture : Go Hasegawa, Professor



Researches on Information Network Architecture for IoT/AI Era

[Research Target and Activities]

Various information network systems have permeated every aspect of society, and the systems built upon them are expected to play an important role in supporting people's daily lives and work, as well as in creating new lifestyles and social structures. Our laboratory conducts research ranging from fundamental to applied studies aimed at realizing these systems.

[Major Achievements in FY2025]

1. In-Network Congestion Control Architecture (Refs. [2][4])

This research proposes a new congestion control architecture for the increasingly diverse future Internet. Specifically, it departs from the traditional end-to-end principle that existing Internet congestion control relies on. Instead, the network between sender and receiver is divided into multiple subnetworks, and congestion control algorithms suited to the characteristics of each subnetwork are applied individually. This approach maximizes the advantages of conventional Internet congestion control technologies developed over many years, while achieving ideal congestion control that maintains high performance even as end-to-end networks become more complex, large-scale, and diverse.

2. Traffic Compression Technology for Network Device Management (Refs. [3][8])

In network device management, it is crucial to collect log data generated by numerous devices in real time and utilize machine learning algorithms for anomaly detection and early failure identification. This research proposes a method for compressing and transmitting text-based log data in real time over networks, even when logs are generated continuously and sporadically from many devices. By synchronizing a tree-structured dictionary between sender and receiver for compression and decompression, the method achieves a higher compression ratio than conventional algorithms.

3. Research on Internet Congestion Control Algorithms (Refs. [1][7])
In the large-scale, highly heterogeneous, and public Internet, it is extremely important to provide fair throughput among competing communication flows. However, in recent years, many methods have been proposed and used that aim solely to maximize the throughput of individual flows. This research proposes a congestion control algorithm that improves throughput fairness among flows and operates efficiently even in highly multiplexed network bottlenecks. Its effectiveness has been demonstrated through experiments in real network environments.

[Staff]

Professor : Go Hasegawa, Dr.
Secretary : Ami Nagashima

[Profile]

Go Hasegawa received the M.E. and D.E. degrees in Information and Computer Sciences from Osaka University, Japan, in 1997 and 2000, respectively. From July 1997 to June 2000, he was Research Assistant of Graduate School of Economics, Osaka University. From 2000 to 2018, he was an Associate Professor of Cybermedia Center, Osaka University. He is now a Professor of Research Institute of Electrical Communication, Tohoku University. His research work is in the area of information network architecture. He is a member of the IEEE and IEICE.

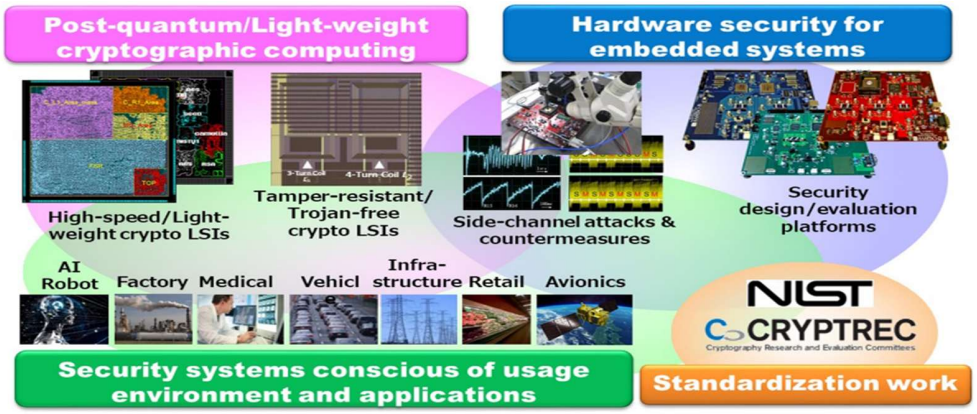
[Papers]

[1] Zewei Han and Go Hasegawa, ‘‘BBR-ES: An Extended-State Optimization for BBR Congestion Control,’’ IEEE Transactions on Network and Service Management, Vol. 23, pp. 2884-2898, 2026.
[2] Mitsuhiro Watanabe and Go Hasegawa, ‘‘Design, discussion, and its potential performance evaluation of in-network congestion control,’’ IEICE Transactions on Information and Systems, Vol.E108-D No.11 pp.1302-1314, Nov. 2025.
[3] Michishiro Tanaka, Go Hasegawa, Ryotaka Miyamoto, Masaki Tsuji and Kazushi Toyoda, Performance evaluation of traffic compression method for large-scale system log collection, in Proceedings of ICETC 2025, November 2025.
[4] Yuki Tabuchi and Go Hasegawa, Low latency data forwarding at in-Network Congestion Control nodes, in Proceedings of APCC 2025, November 2025.
[5] Shoma Yasuda and Go Hasegawa, Decision-Making Strategies for Edge Computing to Optimize Wireless Communication in Local 5G Environments," in Proceedings of IEEE NoF 2025 Workshop, Sep 2025.
[6] Wataru Honda, Go Hasegawa, Yoshihiro Nakahira, and Masayuki Kashima, ``Determining implementation and redundancy configurations of applications based on multi-start hill climbing algorithms," in Proceedings of ASSE 2025, Sep 2025.
[7] Satoshi Utsumi, Keisuke Kano, Salahuddin Muhammad Salim Zabir, Go Hasegawa, ‘‘Ensuring Low Latency When Number of Flows Increases over Bottleneck Link,’’ in Proceedings of the ACM SIGCOMM 2025 Posters and Demos, Sep 2025.
[8] Go Hasegawa, Ryotaka Miyamoto, Masaki Tsuji and Kazushi Toyoda, ‘‘Compressed Transmission of Remote Network Management Information with Synchronized Context-Aware Dictionary,’’ in Proceedings of IEEE HPSR 2025, May 2025.

Environmentally Conscious Secure Information System Laboratory

Advanced information security technology

Environmentally Conscious Secure Information System, Naofumi Homma, Professor
Secure AI System, Akira Ito, Assistant Professor



[Research Target and Activities]

We are studying future secure information communication systems from theories to implementation technologies for constructing advanced information and communication infrastructures in a safe and secure manner. In this year, we have proposed iXTS, a highly efficient authenticated encryption scheme for storage security that adds integrity protection to the XTS mode with negligible overhead. We also revealed a new security threat to cryptographic systems, called XCCA, a machine learning-based side-channel attack that reduces the cost of breaking XEX/XE-structured ciphers by up to 90% compared to conventional methods. In addition, we developed a non-invasive method to detect counterfeit and aged microcontrollers by analyzing the changes of electromagnetic emissions caused by MOSFET degradation, ensuring higher reliability in the semiconductor supply chain.

[Staff]

Professor: Naofumi Homma, Ph. D
Assistant Professor: Akira Ito, Ph. D
Secretary: Mikiko Hattori

[Profile]

Naofumi Homma received the PhD degrees in information sciences from Tohoku University, Sendai, Japan, in 2001. Since 2016, he has been a Professor in the Research Institute of Electrical Communication, Tohoku University. In 2009-2010 and 2016-2017, he was a visiting professor at Telecom ParisTech, Paris, France. He received a number of awards including the IACR CHES Best Paper Award in 2014, the JSPS Prize in 2018, the German Innovation Award in 2018, and Docomo Mobile Science Award in 2022.

[Papers]

[1] Rei Ueno, Akira Ito, Yosuke Todo, Akiko Inoue, Kazuhiko Minematsu, Hibiki Ishikawa, and Naofumi Homma, “All You Need is XOR-Convolution: A Generalized Higher-Order Side-Channel Attack with Application to XEX/XE-based Encryptions,” IACR Transactions on Cryptographic Hardware and Embedded Systems, Vol. 2025, No. 3, pp. 317-360, June 2025.

[2] Yuki Kaneko, Yuichi Hayashi, and Naofumi Homma, “A Non-Invasive Contactless Detection of Recycled Microcontrollers Based on Side-Channel Analysis,” 2025 23rd IEEE Interregional NEWCAS Conference (NEWCAS), pp. 95-99, Paris, France, June 2025.

[3] Akiko Inoue, Kazuhiko Minematsu, Rei Ueno, and Naofumi Homma, “How to Implement Authenticated Encryption on XTS-enabled Devices,” IACR Transactions on Symmetric Cryptology, Vol. 2025, No. 4, pp. 167-198, December 17, 2025.

Aims and Achievements of Human and Bio Information Systems Division

To realize advanced information communications systems, it is essential to understand and apply sophisticated information processing mechanisms of human beings as well as to establish communications environments in which humans can communicate anywhere, anytime without recognizing the communications tools. The aim of this division is to research and develop core and system technologies essential to advanced human-friendly information and communications systems through understanding biological information generation mechanisms, human information processing mechanisms focusing on acoustic and visual inputs, and optimizing the communications environments.

To achieve the goal of the Division, six laboratories have been carrying out research and developments in the following areas: (1) Electromagnetic Bioinformation Engineering, (2) Advanced Acoustic Information Systems, (3) Visual Information and Systems, (4) Real-World Computing, (5) Nano-Bio Hybrid Molecular Devices, (6) Interactive Content Design.

The goals and achievements in the fiscal year 2025 of each laboratory are described in detail below.

(1) Electromagnetic Bioinformation Engineering

(Aims) This laboratory aims to establish two systems: one that captures and utilizes electromagnetic fields from biological and electrical equipment as information, and another that actively acquires biological information. To achieve this, we develop devices that leverage the inherent properties of magnetism by using magnetic materials with controlled microstructures.

(Achievements) The main achievements in 2025 are as follows: (1) To achieve segregation from harmful pests, we developed a system designed to repel them from human habitats using optical and magneto-optical devices. The development involved estimating the necessary laser power and building an integrated tracking system. This system combines three-dimensional position estimation (utilizing twin-camera stereo vision and the YOLO object detection algorithm) with beam steering control via a galvanometer mirror. Its fundamental operation was successfully demonstrated. (2) To realize low-power and highly integrated next-generation communication devices, we developed a two-dimensional magnonic crystal that controls the propagation direction of spin waves. This study represents the world's first report experimentally demonstrating the potential of two-dimensional magnonic crystals as spin-wave waveguides, and these crystals are expected to serve as a foundational element for spin-wave integrated circuits.

(2) Advanced Acoustic Information Systems

(Aims) To propose high-definition communication systems that convey a rich and natural sense of presence. To this end, we are developing acoustic information processing technologies based on well-grounded knowledge of the human auditory system and the multimodal perception processes related to hearing.

(Achievements) In 2025, we investigated the effects of pointing movements on auditory information processing using psychoacoustic and neuroscience techniques. The experiments were conducted under audio-visual and audio-only conditions, and we analyzed the effects from a multimodal information processing perspective. Moreover, the mechanisms of auditory perceptual organization related to spatial hearing were also investigated. In addition, we developed advanced acoustic systems, including 3D virtual auditory displays, sound acquisition systems, and sound reproduction systems. During this fiscal year, we improved sound field recording methods using distributed spherical microphone arrays by introducing theories related to reproducing kernel Hilbert spaces. Furthermore, we proposed a spatial upsampling method for head-related transfer functions using a neural network.

(3) Visual Information and Systems
(Aims) To understand the vision-related brain functions in order to apply the knowledge to realize human-oriented information communication systems.
(Achievements) The major achievements this year are the following three: 1) We constructed and released the first asian-based emotional body motion database (DIEM-A), and clarified the basic dimensions of emotional transmission through body movements by psychological experiments and machine learning analysis. 2) We designed a multi-sequential-choice rapid serial visual presentation (RSVP) paradigm to differentiate the neural mechanisms of self-initiated attention from stimulus-driven attention. The results of EEG measurement showed that the theta band activity from the fronto-central region increases before the onset of the self-initiated attention. 3) We showed the necessary color and luminance conditions for the representation of surface-color appearance using projection mapping technique.

(4) Real-World Computing
(Aims) This laboratory aims at understanding the mechanism underlying the adaptive and resilient behavior of animals from the viewpoint of decentralized control schemes.
(Achievements) The main contributions achieved in 2025 are summarized as follows: (1) We clarified that the functional differentiation of the forelimbs and the control of the body's roll angle are key to the high-speed turning of quadrupeds., (2) We revealed that the key to eels' superior amphibious locomotion lies in an autonomous decentralized control principle that integrates dual sensory feedback based on stretch and pressure sensing., (3) Through detailed observation of millipede walking, we discovered that the body slightly flexes in the pitch direction in coordination with leg movements. Inspired by this finding, we designed a simple leg-trunk coordination control law based on local sensory feedback.

(5) Nano-Bio Hybrid Molecular Devices
(Aims) Our research activities focus on the development of sophisticated molecular-scale devices through the combination of well-established microfabrication techniques and various soft materials, such as biomaterials and organic materials.
(Achievements) The main achievements in 2025 are as follows: (1) We identified a new regulatory factor for the cell membrane, the “horizontal electric field,” and demonstrated that its application increases membrane order. (2) We reproduced, by numerical simulation, the process of localized damage and recovery in cultured neuronal circuits with a modular structure. (3) We successfully detected exosomes, intracellular membrane vesicles, at the single-particle level by resistive pulse sensing using a lipid membrane-coated nanopipette.

(6) Interactive Content Design
(Aims) As the Internet of Things (IoT) expands, everything around us coming online and joining integrated networks. Even everyday items like furniture are going digital. We view all artifacts, physical and digital, as content. Honoring the unique perspectives of people, systems, and the environments they inhabit, we study the interactions between types of content, with the ultimate goal of formulating cohesive, holistic, and intuitive approaches that promote efficiency, ease of use, and effective communication, we focus on content design to enhance living.
(Achievements) The four main achievements of this fiscal year are as follows: (1) Research on 3D user interfaces in XR. We developed new interface technologies to support diverse interactions in AR/MR and VR. (2) Research on generating realistic cyber/virtual spaces using efficient physically based rendering; we developed a focused sampling method to efficiently render circular bokeh and depth-of-field effects that take into account the characteristics of camera lenses. (3) Research on the development of a high-efficiency 3D avatar generation framework under sparse-view conditions and its application to physical AI. We proposed the DNGaussian++ radiance field model, capable of generating high-quality 3D spaces in real time from sparse-view images. By introducing depth regularization and a geometric reorganization mechanism, we significantly improved issues such as shape collapse and local optima under sparse-view conditions—which were previously difficult to address—and achieved high-resolution new-view synthesis at low computational cost. (4) Research on the importance of race in body image perception. We created 3D models of East Asians and South Asians using body scans of these populations. Compared to existing 3D models of Westerners, we confirmed that individuals of East Asian and South Asian descent exhibit different physical changes even at the same BMI. Furthermore, we confirmed that when judging body size, people are unable to accurately estimate the size of body types belonging to races different from their own.

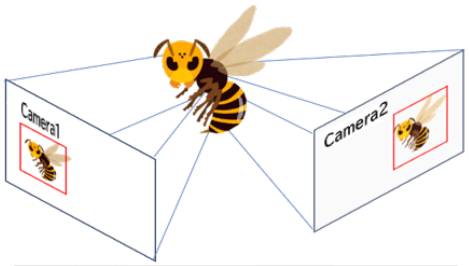
Electromagnetic Bioinformation Engineering

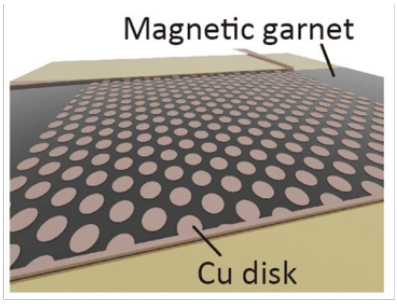
Toward better communication with living organisms

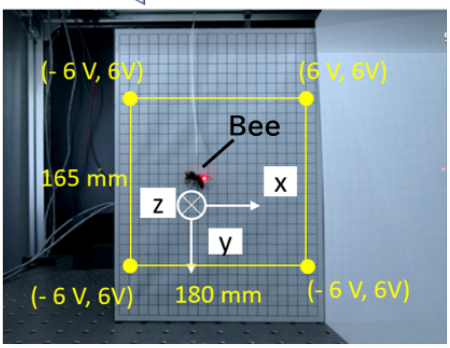
Electromagnetic Bioinformation Engineering, Kazushi Ishiyama, Professor
Electromagnetic Bioinformation Materials, Taichi Goto, Associate Professor

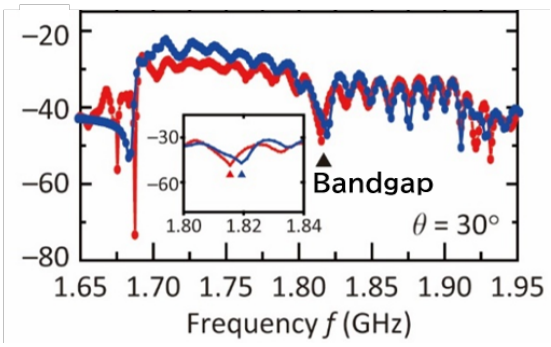
[Research Target and Activities]

This laboratory develops magnetic and magneto-optical devices that exploit controlled microstructures to capture and interact with bioelectromagnetic signals. In 2025, we built a three-dimensional insect-tracking laser system combining stereo vision with galvanometer-based beam steering, and demonstrated a two-dimensional magnonic crystal whose band gap remains nearly invariant over spin-wave incidence angles from 10° to 30°, providing a building block for low-power spin-wave integrated circuits.









[Staff]

Professor: Kazushi Ishiyama, Dr.
Associate Professor: Taichi Goto, Dr.

[Profile]

Kazushi Ishiyama received his MS and PhD degrees in Electrical Engineering from Tohoku University in 1986 and 1993, respectively. His research interests are magnetics and magnetic applications.
Taichi Goto received his MS and PhD degrees in Electronic Information Engineering from Toyohashi University of Technology in 2009 and 2011, respectively. His research interests are magnetic devices and materials.

[Papers]

[1] T. Koguchi, T. Watanabe, H. Miyashita, K. Ishiyama, Y. Nakamura, M. Inoue, M. C. Onbasli and T. Goto, "Evaluation of exchange stiffness constant in iron garnet film using micromagnetic simulation," Applied Physics Letters, Vol. 127, 102407, 2025
[2] T. Goto, T. Koguchi, Y. Yoshihara, H. Miyashita, K. Mori, T. Watanabe, A. C. Kaczmarek, P. B. Lim, M. Inoue, C. A. Ross and K. Ishiyama, "Magnetotaxial perpendicular magnetic anisotropy and enhanced Faraday rotation in ion beam sputtered cerium-substituted yttrium iron garnet," ACS Applied Optical Materials, Vol. 3, pp. 2923-2934, 2025

Advanced Acoustic Information Systems

Towards high-level acoustic information communication systems

Advanced Acoustic Information Systems: Shuichi Sakamoto, Professor

[Research Target and Activities]

Our research goal is to clarify how humans process information through "hearing," which is one of the most important modalities in human perception. In addition, we investigate the multimodal processing of auditory and visual information, as well as proprioception. Our findings are applied towards the development of advanced acoustic communication systems and user interfaces, including the realistic and comfortable expression of three-dimensional (3D) sound spaces. One typical example is the development of new type of 3D auditory displays, which present spatial sound images by simulating the transfer functions for the sound paths from the sound sources to the listeners' external ears. Another example is the proposal of 3D sound field information sensing systems. These systems are expected to convey a high-quality virtual sound space, which is keenly sought for multimedia communications, cyberspace systems, and virtual reality systems.

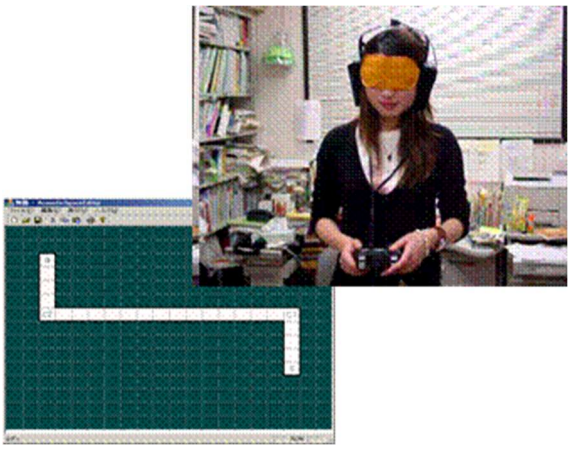


Fig. 1 Application for the training of spatial cognition using a high-definition virtual auditory display

In FY2025, we focused on the mechanisms of auditory selective attention. Auditory selective attention plays a crucial role in the cocktail party effect, which is a well-known phenomenon describing how target sounds are extracted from complex auditory scenes. This year, we investigated the masking effects of a contralateral distracting sound observed in patients with listening difficulties. The results of a dichotic word intelligibility test revealed that the masking effect is more pronounced with music containing lyrics than with continuous steady noise [1]. Furthermore, we investigated an advanced sound field recording and reproduction method using distributed spherical microphone arrays based on reproducing kernel Hilbert spaces [2]. We also developed a novel comparison calibration system for digital-output infrasound sensors [3].

[Staff]

Professor: Dr. Shuichi Sakamoto

[Profile]

Shuichi Sakamoto graduated from Tohoku University in 1997 and received his Ph. D. degree in 2004 also from Tohoku University. His research interests include human auditory and multisensory information processing and development of advanced multimodal information systems. From 2025, he was serving as a vice president of the Acoustical Society of Japan.

[Papers]

[1] T. Kawase, C. Obuchi, J. Suzuki, Y. Katori, and S. Sakamoto , “Masking effects caused by contralateral distractors in participants with versus without listening difficulties,” Ear and Hearing, 46(2), pp. 393-400 (2025).

[2] K. Yanagiya, S. Sakamoto, and S. Jung, “Sound field recording and reproduction method using distributed spherical microphone arrays based on kernel ridge regression,” Proc. The 25th International Congress on Acoustics, 3pSP4 (2025).

[3] K. Hirano, H. Takahashi, K. Yamada, H. Nozato, and S. Sakamoto, “Comparison calibration system for digital-output infrasound sensors,” Measurement Science and Technology, 37, 075106 (2026).

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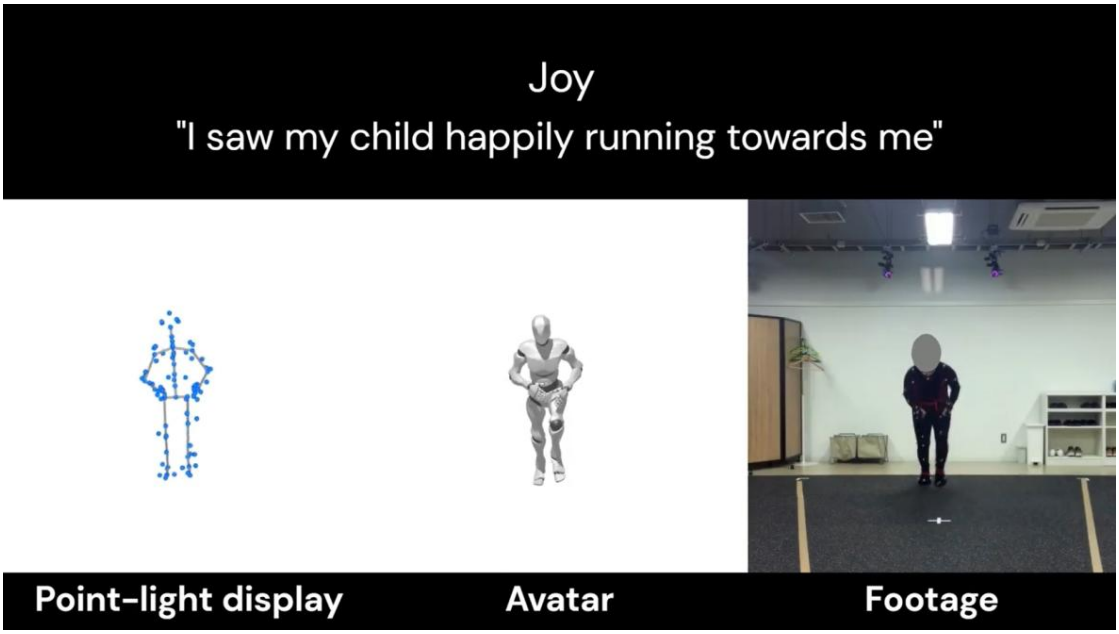
Visual Cognition and Systems Laboratory

Understanding human visual system for the better communication with visual information

Visual Information and Systems: Kowa KOIDA, Professor
Attention and Learning Systems: Chia-huei TSENG, Associate Professor

[Research Target and Activities]



Our target is to understand the vision-related brain functions in order to apply the knowledge to realize human oriented information communication systems. In 2025, our major achievements were the followings.

1) Affective Understanding from Body Motion
To investigate how actions lead to intention expression and understanding and how the cultures influence this capacity is clarified, we approached these endeavors from machine learning and human perception. We have: (1) completed and published the first Asian-based emotional body motion database (DIEM-A), which includes 10,000+ multi-modal data including videos, text, 3-D body motion; (2) conducted human perception study to examinate the characteristics of our interpretation from embodied information. (3) applied motion learning algorithms to use data-driven perspectives to look for fundamental dimension of affective understanding from body motion.

2) Neurophysiological Study of Attention
We designed a multi-sequential-choice rapid serial visual presentation (RSVP) paradigm with identical visual inputs to dissociate internal and external determinants of attention. Participants performed attentional task while EEG was recorded. We observed a frontal-midline theta ramping before self-initiated shifts, suggesting a preparatory buildup of cognitive control specific to internally driven shifts.

3) Surface color perception conditions in projection mapping.
Projection mapping (PM) is generally performed by projecting light on an object in a dark environment, so the target appears to emit light. If PM is performed by

arranging many projectors in a room so that the light does not hit only the target object, it becomes like being illuminated by "black light." In this study, we investigated whether the target appears to emit light or as the reflected color of the object surface with various colors and textures, and confirmed that the characteristics known for two-dimensional planes are also effective for three-dimensional objects under PM.

[Staff]

Professor ： Kowa Koida, Ph.D.
Associate Professor ： Chia-huei Tseng, Ph.D.

[Profile]

Kowa KOIDA: He graduated from the Department of Applied Physics, Faculty of Science, Tokyo Institute of Technology in 1995 and received PhD from the Graduate School in 2000. From 2000, he worked at the National Institute for Physiological Sciences as a postdoctoral fellow and assistant professor. From 2010, he worked at Toyohashi University of Technology as an associate professor. Since October 2025, he has been a Professor at the Research Institute of Electrical Communication, Tohoku University. He specializes in visual neurophysiology, psychophysics, and color vision, and currently serves as secretary of the Vision Society of Japan and a Council member of the Asia Pacific Conference on Vision. He received the Vision Society of Japan Ukai Paper Award in 2025.

Chia-huei TSENG: She received her PhD from The University of California, Irvine, U.S.A. after a B.S. and B.M.S. from National Taiwan University. She was a post-doc researcher at Laboratory of Vision Research at the Center for Cognitive Science, Rutgers University, New Jersey. Before joining Tohoku University, she was a university professor in Taiwan and Hong Kong.

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Real-world Computing

Toward Understanding Design Principle for Life-like Resilient Systems

Real-world Computing, Akio Ishiguro, Professor

[Research Target and Activities]

Living organisms exhibit surprisingly adaptive and versatile behavior in real time under unpredictable and unstructured real world constraints. Such behaviors are achieved via spatiotemporal coordination of a significantly large number of bodily degrees of freedom. Clarifying these remarkable abilities enable us to understand life-like complex adaptive systems as well as to construct truly intelligent artificial systems. A prominent concept for addressing this issue is "autonomous decentralized control", in which non-trivial macroscopic functionalities are emerged via spatiotemporal coordination among vast amount of autonomous components that cannot be explained solely in terms of individual functionality. We study the design principle of autonomous decentralized systems that exhibit life-like resilient behaviors from the viewpoints of robotics, mathematics, nonlinear science, and physics.

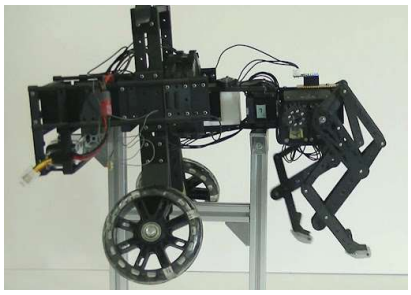

Fig.1: Prototype of the quasi-quadruped robot developed

Fig.2: Amphibious locomotion of an eel-like robot via decentralized control

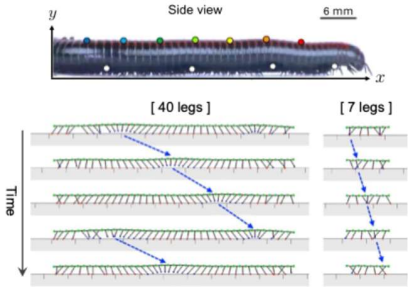

Fig.3: Millipede-inspired decentralized trunk−limb coordination rule for many-legged walking

[Staff]

Professor: Akio ISHIGURO, Dr.
Assistant Professor: Akira FUKUHARA, Dr.
Assistant Professor: Kotaro YASUI, Dr.
Assistant Professor: Shura SUZUKI, Dr.

[Profile]

Akio ISHIGURO received B.E., M.E., and Ph.D. degrees from Nagoya University in 1987, 1989, and 1991, respectively. From 1991 to 1997, he was with Nagoya University as an assistant professor. From May 1997 to 2006, he was an associate professor, Nagoya University. From 2006 to 2011, he was a professor of the Graduate School of Engineering, Tohoku University. Since April 2011, he has been a professor of Research Institute of Electrical Communication, Tohoku University. His main research interests are in bio-inspired robotics, nonlinear dynamics. He received 2004 IROS Best Paper Award, 2008 Ig Nobel Prize (Cognitive Science Prize), 2012 IEEE/RSJ JCTF Novel Technology Paper Award for Amusement Culture Finalist, Living Machines 2012 Best Paper Award.

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Nano-Bio Hybrid Molecular Devices

Development of novel bio-devices through the combination of nanotechnology and biomaterials

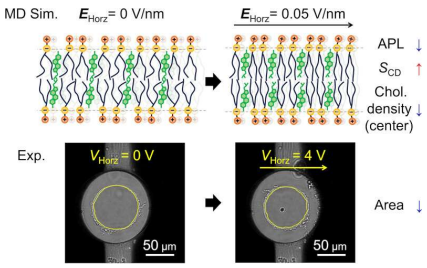
Nano-Bio Hybrid Molecular Devices: Ayumi Hirano-Iwata, Professor

[Research Target and Activities]

Our research focuses on the development of sophisticated molecular-scale devices by integrating well-established microfabrication techniques with various soft materials.

1. Anisotropic Membrane Response to Electric Field Direction

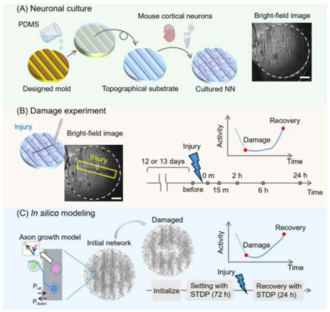
The lipid bilayer supports diverse membrane proteins in cell membranes. This year, we investigated the effects of horizontal electric fields ($\boldsymbol{E}_{\mathrm{HORZ}}$) on lipid bilayers using molecular dynamics simulations and bright-field imaging. We found that $\boldsymbol{E}_{\mathrm{HORZ}}$ induces membrane area contraction and acyl-chain ordering, whereas normal electric fields ($\boldsymbol{E}_{\mathrm{VERT}}$) of the same strength have little effect. This work was published in *The Journal of Physical Chemistry Letters* [1].



Effect of $\boldsymbol{E}_{\mathrm{HORZ}}$ on lipid bilayers

2. Modular architecture and damage recovery in neuronal networks

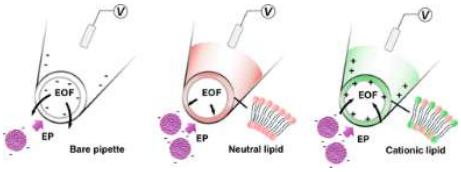
We numerically modeled the damage response and recovery of cultured neuronal networks with modular architecture. Using a spike-timing-dependent plasticity (STDP) rule, the model reproduced the experimental observation that spontaneous collective activity, transiently reduced by a focal lesion, recovers to pre-damage levels within 24 hours. The combination of modular architecture and plasticity confers robustness to damage, and information representation evaluated within a reservoir computing framework also recovers alongside network-wide activity. This work was published in *Frontiers in Neuroscience* [2].



Recovery of damaged neuronal networks

3. Development of lipid membrane-coated nanopipette for EV sensing

Lipid membrane was coated on nanopipettes, thereby controlling the interfacial properties and significantly improving the transport efficiency of exosomes. This work was published in *ACS Appl. Mater. Interfaces* [3].



Lipid membrane-coated nanopipette

[Staff]

Professor: Ayumi Hirano-Iwata, Dr.
Assistant Professor: Maki Komiya, Dr., Kaoru Hiramoto, Dr.

[Profile]

Ayumi Hirano-Iwata 2016– RIEC, Tohoku University, Japan, Professor, Doctor of Science. Memberships: The American Chemical Society. The Japan Society of Applied Physics, The Japan Society of Vacuum and Surface Science.

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Contact to Professor HIRANO Ayumi : ayumi.hirano.a5@tohoku.ac.jp

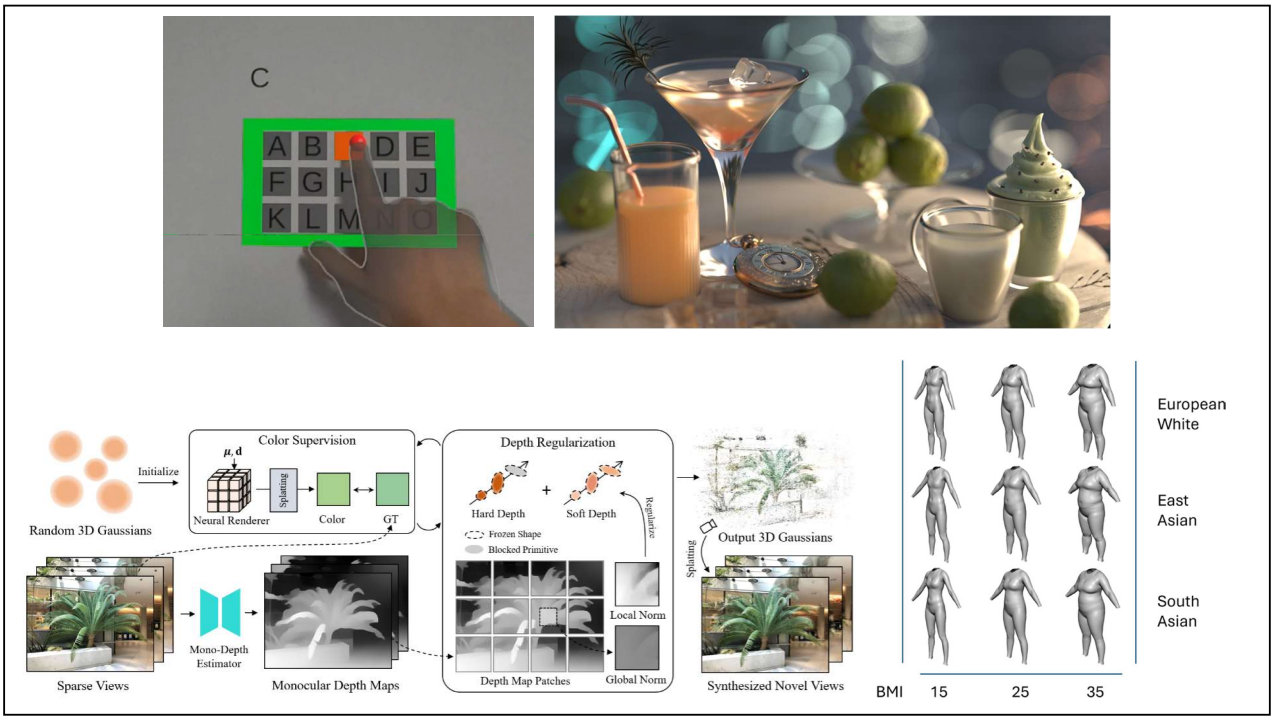
Interactive Content

Technologies for Interactive Content

Interactive Content Design Yoshifumi KITAMURA, Professor
Human-Workspace Interaction Kazuyuki FUJITA, Associate Professor

[Research Target and Activities]

As IoT expands, everything around us coming online and joining integrated networks. Even everyday items like furniture are going digital. We view all artifacts, physical and digital, as content. Honoring the unique perspectives of people, systems, and the environments they inhabit, we study the interactions between types of content, with the ultimate goal of formulating cohesive, holistic, and intuitive approaches that promote efficiency, ease of use, and effective communication.



In this year, we worked on 3D user interfaces for XR, including thumb-based text entry on small XR keyboards, touch input on everyday physical surfaces in AR/MR, and bimanual 3D manipulation in VR; an efficient physically based rendering method for circular bokeh and depth-of-field effects; a framework for high-quality 3D avatar generation from sparse-view images based on radiance field models; and a study on the importance of race in body image perception using 3D body models of East and South Asian people.

[Staff]

Professor: Yoshifumi Kitamura, Dr.
Associate Professor: Kazuyuki Fujita, Dr.
Assistant Professor: Yumi Hamamoto, Dr.
Assistant Professor: Gu Lin, Dr.

[Profile]

Yoshifumi Kitamura: He is active in academic and professional communities, and has served in positions such as the Japan Liaison of IFIP TC-13 (Human-Computer Interaction), Japan Liaison and Chair of ACM SIGCHI Asian Development Committee, Chair of Japan ACM SIGCHI Chapter, Steering Committee Chair of ACM VRST, SIGGRAPH Asia 2015 Conference Chair, General Chair of ACM CHI 2021. His formal education was obtained at Osaka University, B.Sc (1985); M.Sc. (1987); and Ph.D. (1996).

Kazuyuki Fujita: He received his Ph.D. in Information Science and Technology from Osaka University in 2013. He worked for ITOKI, an office space design company, and was engaged in research and development on future offices for 2013-2018. From 2018 to the present, He has been working at RIEC, Tohoku University (as Assistant Professor in 2018-2024 and as Associate Professor from 2024). He has also been granted the title of Prominent Research Fellow at Tohoku University in 2023.

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[7] Miao Cheng, Chiahuei Tseng, Victor Schneider, Ken Fujiwara and Yoshifumi Kitamura, Asian Emotional Body Movement Database: Diverse Intercultural E-Motion Database of Asian Performers (DIEM-A), 13th International Conference on Affective Computing and Intelligent Interaction (ACII ’25), October 2025

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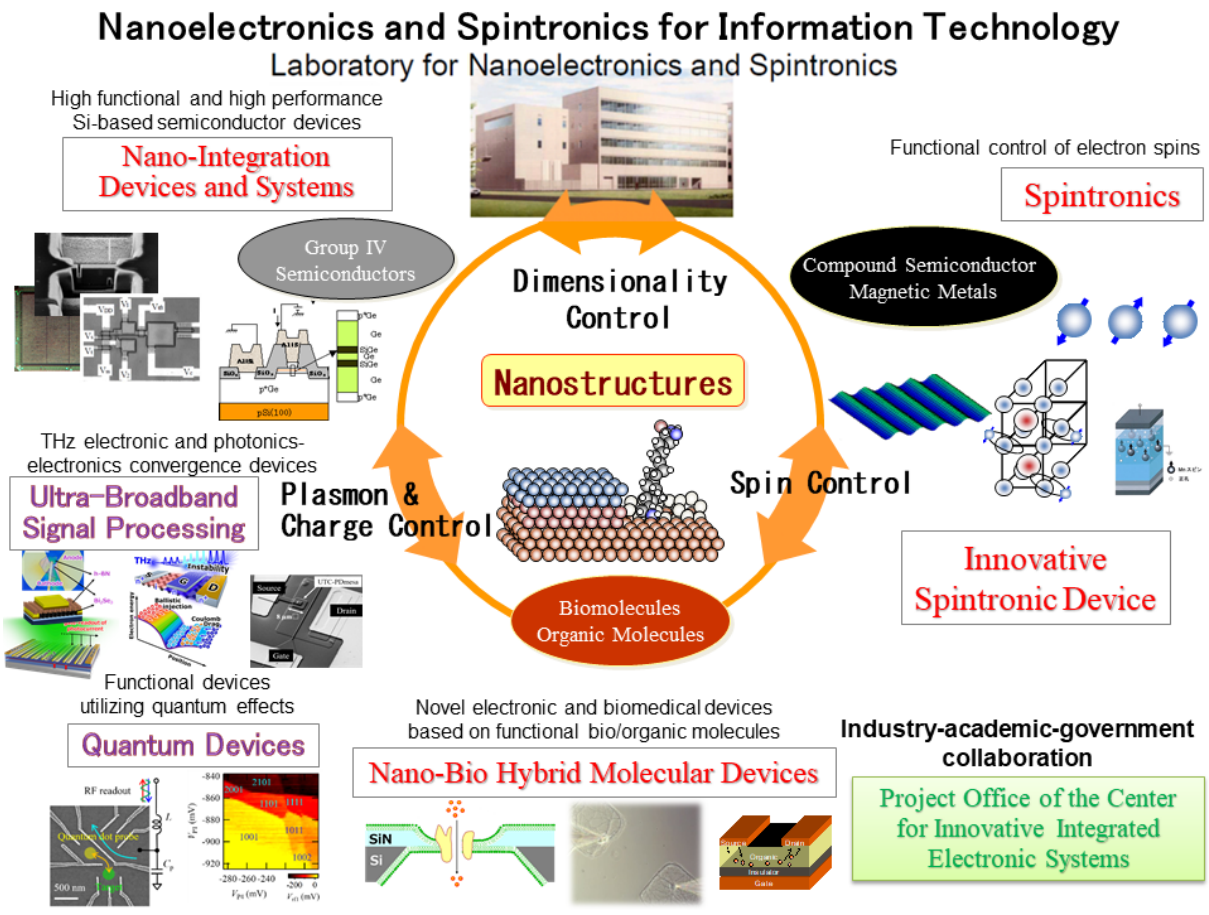
[15] J. Kanzawa, R. Kurokawa, T. Takamura, N. Nohara, K. Kamiya, Y. Moriguchi, Y. Sato, Y. Hamamoto, T. Shoji, T. Muratsubaki, M. Sugiura, S. Fukudo, Y. Hirano, Y. Sudo, R. Kamashita, S. Hamatani, N. Numata, K. Matsumoto, E. Shimizu, N. Kodama, S. Kakeda, M. Takahashi, S. Ide, K. Okada, S. Takakura, M. Gondo, K. Yoshihara, M. Isobe, K. Tose, T. Noda, R. Mishima, M. Kawabata, S. Noma, T. Murai, K. Yoshiuchi, A. Sekiguchi, O. Abe. “Brain network alterations in anorexia Nervosa: A Multi-Center structural connectivity study”, NeuroImage: Clinical, 2025.

Laboratory for Nanoelectronics and Spintronics

The Laboratory for Nanoelectronics and Spintronics of the Research Institute of Electrical Communication (RIEC) was established in April of 2004. Its purpose is to develop and establish the science and technology of nanoelectronics and spintronics for information technology. Utilizing the facilities installed in the Nanoelectronics-and-Spintronics building and under collaboration between RIEC and related laboratories of the Graduate Schools of Engineering, Information Sciences, Biomedical Engineering, of Tohoku University, R&D on nanotechnologies of materials and devices in Nanoelectronics and Spintronics are continued extensively. Furthermore, nation-wide and world-wide collaboration research projects are conducted to build a systematic database in electrical communication research.

The Laboratory for Nanoelectronics and Spintronics mainly consists of laboratories of Nano-Integration Devices and Systems, Spintronics, Nano-Bio Hybrid Molecular Devices, and Innovative Spintronic Device; together with the project office of the Center for Innovative Integrated Electronic Systems, the Cooperation Section, and the groups of Ultra-Broadband Signal Processing and Quantum Devices. These groups cooperatively carry out the research aimed at establishing a world-wide Center of Excellence (COE) in the research area of nanoelectronics and spintronics.



Highlights of our research activities in 2025 are shown below.

Nano Integration

● Nano-Integration Devices and Systems (S. Sato, M. Sakuraba, and H. Yamamoto)

(1) We integrated the analog circuit block with an energy-harvesting circuit in a reservoir computing system based on an extremely low-power SNN (spiking neural network), and demonstrated that the reservoir layer can operate solely on harvested energy. In addition, toward scaling up the SNN, we successfully designed an inter-neuron spike-routing circuit that enables multi-chip operation.
(2) We found that introducing a B atomic layer of 0.12 or more atomic layers into the 4H-SiC MOS interface significantly expands the hysteresis of the C-V curve of an Al gate MOS diode. Furthermore, we fabricated a pn diode using highly doped Si deposited by ECR plasma CVD and successfully created an Esaki diode that exhibits negative differential resistance at an appropriate undoped Si layer thickness.
(3) We demonstrated a novel application of cultured neuronal networks in physical reservoir computing. By applying FORCE learning to the activity of rat cortical neurons, we showed that the system can autonomously generate various temporal signals.

Spintronics and Information Technology

● Spintronics (S. Fukami and S. Kanai)

Our research activities focus on realizing low-power functional spintronic devices. The outcomes in the last fiscal year are as follows: (1) the phase diagram of the spin structure of non-collinear antiferromagnetic Mn-Sn thin films with respect to temperature and composition was shown, and it was clarified that the non-collinear spin structure is maintained even at cryogenic temperatures, in Mn-rich regions compared to the stoichiometric composition; (2) the Dzyaloshinskii-Moriya interaction at the interface between a non-collinear antiferromagnet and a heavy metal acting as uniaxial magnetic anisotropy for the non-collinear antiferromagnet was theoretically elucidated; (3) strong coupling states between optical and acoustic magnons controlled by applying an electric current in artificial antiferromagnetic structures was experimentally shown, and the underlying mechanism was theoretically clarified; (4) the reversal of the chiral spin structure of non-collinear antiferromagnetic Mn_3Sn nanodots driven by sub-ns/ns current pulses was measured, and the advantages of antiferromagnets over the ferromagnets conventionally used in the field of spintronics were demonstrated; (5) the size dependence of device characteristics for synthetic antiferromagnetically coupled stochastic magnetic tunnel junctions used as probabilistic bits was experimentally clarified; (6) the thermal fluctuations of the chiral spin structure of non-collinear antiferromagnets were theoretically investigated, and the potential to achieve faster thermal fluctuations compared to those of conventional ferromagnets was revealed; (7) the dominant factors in current-induced chiral spin reversal of non-collinear antiferromagnetic Mn_3Sn thin films were isolated, and the conditions under which spin-orbit torque acts more dominantly than

Joule heating were identified; (8) the scaling law for the coherence time of quantum spins associated with point defects in 2D materials was clarified, and the differences compared to 3D materials were discussed; (9) a probabilistic bit circuit suitable for large-scale integration that eliminates the need for the digital-to-analog converters (DACs) used in conventional probabilistic bits was proposed and verified, and its potential for large-scale combinatorial optimization problems is demonstrated.

● **Ultra-Broadband Signal Processing ((T. Hirooka), A. Satou, and T.-T. Lin)**

The goal of our research is to explore the millimeter-wave/terahertz (THz) frequency range by creating novel integrated electron devices and circuit systems. III-V- and graphene-based heterostructures for creating new types of THz devices and photnoics-electronics-convergence devices are major concerns. We are developing future ultra-broadband wireless communication systems as well as spectroscopic/imaging systems for safety and security. The followings are the major achievements in 2025 FY.

(1) Development of THz plasmonic detectors

We proceeded the research of a THz detector based on InGaAs-channel high-electron mobility transistor (HEMT) utilizing the plasmonic 3D rectification effect, which is a multiplication of the plasmonic hydrodynamic nonlinearities and the diode current nonlinearity between the gate and channel. We revealed that the rise of the channel potential due to the dc current flow causes the weakening of the 3D rectification effect and succeeded in enhancing the detector internal responsivity by introducing an electrode structure that strengthens the channel grounding.

(2) Development of photonics-electronics convergence devices

We fabricated an InGaAs-channel grating-gate HEMT integrated with a uni-traveling-carrier photodiode (UTC-PD) and have demonstrated the heterodyne detection operation at the 300-GHz band using it.

(3) Development of THz detectors based on low-dimensional-material heterostructures

We proposed a theoretical framework for THz detection based on heterostructures combining low-dimensional Dirac semimetals, such as graphene, with layered semiconductors, such as black phosphorus. Furthermore, using our laboratory's proprietary Hot Transfer technique, we fabricated low-dimensional material heterostructures and demonstrated high-speed THz detection with a response time on the order of 200 ps under zero-bias and zero-power-consumption conditions.

● **Quantum Devices (T. Otsuka)**

We are exploring interesting properties of solid-state nanostructures utilizing precise and high-speed electrical measurement and control techniques. We are also developing materials and devices using nanostructures. Our research activities in FY 2025 are as follows.

(1) We developed electronic measurement and control methods for local electronic states in nanostructures utilizing semiconductor quantum dots. We improved measurement and control techniques using cryogenic devices, high-speed circuits, and novel materials.

(2) We measured local electronic and spin states in nanostructures using sensitive electronic measurement techniques. We investigated electronic transport phenomena in semiconductor quantum dots and novel nanostructures.

(3) We studied semiconductor quantum devices and systems for quantum information processing. We investigated the measurement and control of quantum states, and developed scalable quantum-device technologies and devices based on novel materials.

Nano-Bio Hybrid Molecular Devices

● **Nano-Bio Molecular Devices (A. Hirano-Iwata)**

Our research activities focus on development of sophisticated molecular-scale devices through the combination of well-established microfabrication techniques and various soft materials, such as biomaterials and organic materials.

(1) The lipid bilayer provide a structural platform for diverse membrane proteins in cell membranes. This year, we investigated the effects of horizontal electric fields (EHORZ) on lipid bilayers using molecular dynamics simulations and bright-field imaging. We found that EHORZ induces membrane area contraction and acyl-chain ordering, whereas normal electric fields (EVERT) of the same strength exert little effect.

(2) We numerically modeled the damage response and recovery of cultured neuronal networks with modular architecture. Using a spike-timing-dependent plasticity (STDP) rule, the model reproduced the experimental observation that spontaneous collective activity, transiently reduced by a focal lesion, recovers to pre-damage levels within 24 hours. The combination of modular architecture and plasticity confers robustness to damage, and information representation evaluated within a reservoir computing framework also recovers alongside network-wide activity.

(3) We developed lipid membrane-coated nanopores for resistive pulse sensing of exosomes, which are small extracellular vesicles secreted for intercellular communication. By coating nanopipettes with lipid membranes, we controlled the interfacial properties of the nanopores and significantly improved the transport efficiency of exosomes.

Research Targets and Activities of Laboratory for Brainware Systems

The Laboratory for Brainware Systems of the Research Institute of Electrical Communication was established in 2004 and renewed in 2014. Its purpose is to contribute to the research and development of advanced information science and technology for Brainware systems which realize a seamless fusion of the changeable and complex real world and the cyber space.

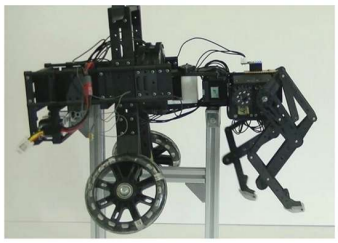
We aim at establishing scientific and technological foundations and at exploring human-like brainware computing applications for Adaptive Cognition and Action Systems Division (Recognition and Learning Systems Group), Autonomous Decentralized Control Systems Division (Real-World Computing Group), Brainware LSI Systems Division (New Paradigm VLSI System Group), and Brain Architecture Division. The Laboratory for Brainware Systems consists of the above four divisions which cooperatively carry out the research. At the same time, they serve as a laboratory for nation-wide cooperative research in the field of Brainware systems.

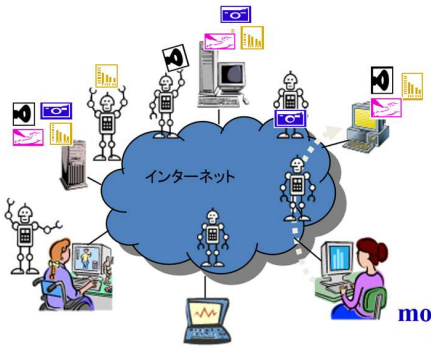
The technology developed in the Laboratory is expected to enhance the research carried out in the four Divisions of the Institute, and the research conducted in the Divisions, in turn, is expected to provide scientific basis for the information technology developed in the Laboratory.

Physical and Adaptive Hardware Environment

・Brain-Like Computing

(Brain Architecture)

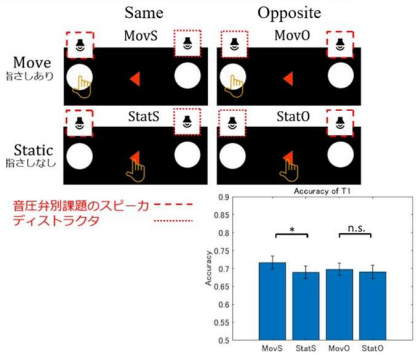




・Real-World Dynamical Intelligence

(Real-World Computing)

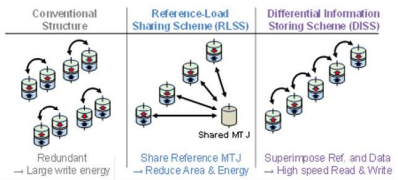
Seamless Fusion of Real World and Multi-Modal Computing



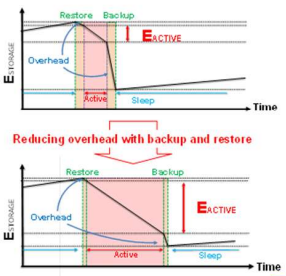
・Interaction between pointing-movement and auditory spatial attention

(Recognition and Learning Systems)

Hardware Environment with Massively Parallel Brain LSI

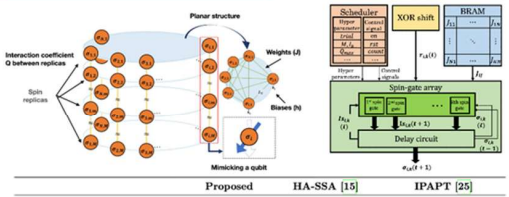


	Conventional	RLSS	DISS
MTJ Devices	64	48	33
Backup Time	30 ns	240 ns	60 ns
Backup Energy	0.44 nJ	0.22 nJ (-48%)	0.23 nJ (-46%)
Cell Area	871 um²	551 um² (-37%)	668 um² (-23%)



・Novel MTJ-based NV-FF circuitry

(New Paradigm VLSI System)



	Proposed	HA-SSA [15]	IPAPT [25]
Hardware architecture	Spin serial	Spin parallel	Spin parallel
Graph support	Fully connected	Limited to 4 neighbors	Limited to 4 neighbors
Number of connections per spin	up to 799	4	4
Bit width of h and J supported	4	4	2
Energy	1.093 mJ	2.138 mJ	N/A
Mean cut value	558.4	558	561

・Energy-Efficient Quantum-Inspired Annealing Hardware

[Research Target]

The goal of this facility is to develop fundamental technologies and their applications that will lead the world to the next-generation information system that seamlessly integrates the cyber-physical world and the ever-changing real world. In order to realize this goal, each laboratory participating in this facility has set the following individual goals and promotes research activities as follows:

Real-World Computing Section: Animals exhibit adaptive locomotion under unpredictable and unstructured environments by coordinating their large number of bodily degrees of freedom in real time. We aim to understand the design principle of such adaptive locomotion by focusing on autonomous decentralized control wherein macroscopic behaviors emerge from local interactions among each individual components. Moreover, we aim to develop artificial agents (*e.g.* robots) that function like animals by implementing the obtained design principle.

New Paradigm VLSI System Section: Rapid progress in recent deep submicron regime has led the capability to realize giga-scaled embedded systems on a chip (SoC), while performance degradation of SoCs due to wiring complexity, power dissipation and device-characteristic variation are increasingly getting serious problems in the recent VLSI chip. Our research activity is to solve the above problems primarily by the following two ways: the use of logic-in-memory architecture based on nonvolatile logic, and the use of asynchronous data-transfer schemes based on multiple-valued current-mode logic, which would open up a novel VLSI chip paradigm, called a "new-paradigm VLSI system."

Recognition and Learning Systems Section: Humans can perform various actions based on the recognition of the outside world that is constructed through multiple sensory inputs such as vision and touch, even though they frequently move their own body parts in the environment. Here we investigate the adaptive-process and functions of the human cognitive system for action through psychophysical experiments. On the basis of the experimental evidence, we aim to create computational models of the recognition and learning processes in the human brain.

[Research Activities]

Aiming at the seamless integration of the cyber-physical world and the real world, which is the goal of Laboratory of Brainware Systems, the following research results were obtained. In particular, the following research results in fiscal year 2025 are an important step towards the goal as:

-- Real-World Computing Section has proposed decentralized locomotor circuits for adaptive amphibious locomotion of an eel-like robot.
https://doi.org/10.1073/pnas.2422248122

--New Paradigm VLSI System Section has succeeded in reducing the power consumption of a p-bit-based fully connected simulated annealing system utilizing BRAM, paving the way toward solving the interconnection problem in fully connected architectures.
https://doi.org/10.1109/ACCESS.2026.3651741

--Recognition and Learning Systems section has reported larger masking effects due to a contralateral distractor sound observed in patients with listening difficulties.
https://doi.org/10.1097/AUD.0000000000001591

The more detailed research results of each section (laboratory) are shown as follows:

Real-World Computing Section:
(refer to Real-World Computing Laboratory in Human Information Systems Division)

New Paradigm VLSI System Section:
(refer to New Paradigm VLSI System Laboratory in Systems & Software Division)

Recognition and Learning Systems Section:
(refer to Visual Cognition and Systems Laboratory in Human Information Systems Division)
(refer to Advanced Acoustic Information Systems Laboratory in Human Information Systems Division)

Recognition and learning systems laboratory

Understanding the human recognition and learning systems

(Advanced Acoustic Information Systems, Shuichi Sakamoto, Professor)

[Research Target and Activities]

To develop computational models of how the human brain integrates multiple sensory inputs from the external world, we are investigating visual and auditory functions in the human brain to implement these processes in hardware under biologically plausible conditions. Our approaches include psychophysics, brain wave measurements, and computer simulations.

This year, we first investigated the effects of hand movements on visual and auditory spatial attention. Hand movements facilitate visual processing at the location of the movement goal, suggesting enhanced visual attention at the location indicated by the hand. However, it remains unclear whether a similar facilitation occurs in auditory processing. Behavioral results showed higher accuracy at the pointed location than at other locations in the visual task, whereas this effect was not observed in the auditory task. These findings suggest that movement preparation enhances visual processing at the movement goal while having little or no effect, or at least a much smaller effect, on auditory processing.

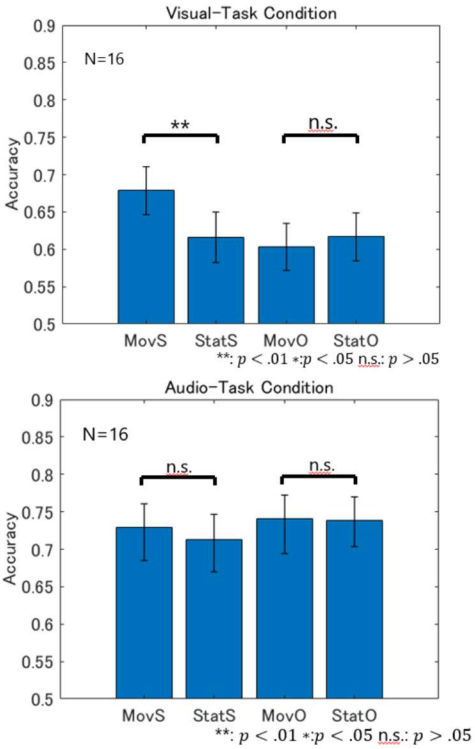


Fig. 1: Target detection performance for visual (top) and auditory (bottom) conditions.

Second, we investigated the effect of auditory spatial attention to distance on auditory spatial resolution. In the experiment, sound sources were arranged linearly at distances ranging from 25 cm to 200 cm from the listeners, who were instructed to focus their attention on a specific distance. Their task was to determine the relative position of two sequentially presented auditory stimuli. The results revealed that auditory spatial attention significantly affects the just noticeable difference (JND) in distance discrimination between two sound stimuli. This finding suggests that auditory attention to a particular distance contributes to improved spatial resolution.

[Staff]

Professor: Shuichi Sakamoto, Ph.D.

[Papers]

[1] Z. Li, S. Sakamoto, S. Shioiri, “Effects of hand pointing movements on visual and auditory spatial attention,” Proc. 23rd International Multisensory Research Forum (IMRF), 33, pp. 105-105 (2025).

[2] T. Kato and S. Sakamoto, “Effect of auditory attention to distance on the accuracy of auditory distance discrimination,” IEICE Technical Report, EA2025-22, 55-59 (2025).

Research Center for 21st Century Information Technology

Research and Development of the IT-Based Practical Technology by the Industry-Academia-Government Collaboration

[Research Target and Activities]

The purpose of the IT-21 center is development of practical technologies for IT based on the advanced technologies of RIEC with the partnership among Industry, Government and University. The term of development is limited less than 5 years. The projects are planned on matching with both basic technologies in the University and application in the Industry. Combination of the technologies of the University and Industry makes practical technologies with availability for the commercial products. The center actively accelerates to obtain the intellectual properties generated from the development of practical technology to the Industry. The center consists of three divisions, "Industry-Academia-Government-Collaboration Research and Development Division", "Interdisciplinary Collaboration Research Division", and "Exploratory Research Division".

[Staff]

Director: Noriharu Suematsu, Professor

Industry-Academia-Government-Collaboration Research and Development Division
(Wireless ICT platform project)
Noriharu Suematsu, Project Leader, Professor
Takashi Shiba, Specially Appointed Professor
Satoshi Tsukamoto, Specially Appointed Professor
Satoko Itaya, Visiting Professor
Takashi Mehata, Visiting Associate Professor
Tamotsu Nishino, Research Fellow

(AI Hardware Security Project)
Naofumi Homma, Project Leader, Professor

Interdisciplinary Collaboration Research Division
(No project)

Challenging and Exploratory Research Division
Yoshifumi Kitamura, Project Leader, Professor
Noriharu Suematsu, Project Leader, Professor
Naofumi Homma, Project Leader, Professor

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IT21 Center Industry-Academia-Government-Collaboration Research and Development Division, Wireless ICT Platform Project

Dependable Air

Noriharu Suematsu, Professor (Project Leader)
Takashi Shiba, Specially Appointed Professor
Satoshi Tsukamoto, Specially Appointed Professor
Tamotsu Nishino, Research Fellow

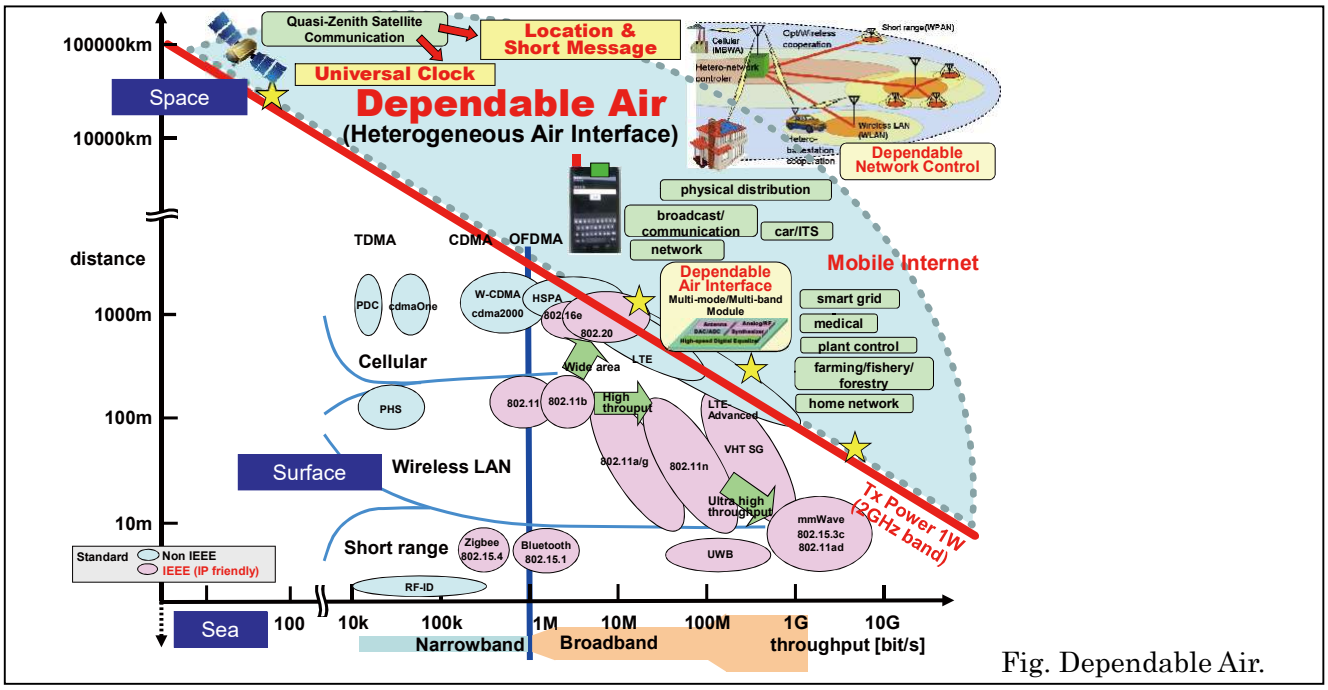


Fig. Dependable Air.

[Research Target and Activities]

Mobile wireless communication technology is one of the significant communication technologies that support the Information and Communication Technology (ICT) society, connected with the high-speed backbone network using optical fiber. Evolution of the mobile wireless communication technology in Japan is indispensable to keep the leadership in this technology area in the world. The mobile wireless technology group has been proposing the concept of "Dependable Air," which is a heterogeneous and highly-reliable wireless network. The Dependable Air is able to work even in the event of a big disaster. The group proceeded a R&D project "R&D on Technologies to Densely and Efficiently Utilize Radio Resources of Unlicensed Bands in Dedicated Areas" supported by the Ministry of Internal Affairs and Communications (MIC) from 2017. The group had also proceeded R&D project "R&D on Adaptive Media Access Control for Increasing the Capacity of Wireless IoT Devices in Factory Sites" supported by the Ministry of Internal Affairs and Communications from 2019. From 2020, the group started sub-10GHz/28GHz Si RFICs for B5G station under the R&D project supported by NEDO. From 2022, the group start two R&D projects relating to spectrum monitoring and sensing of wireless IoT for smart factories under the support of MIC. The group also launch a new R&D project relating to millimeter-wave NTN B5G LEO constellation satellite communication systems and on-board DBF antenna/devices under the support of NICT.

[Staff]

Professor: Noriharu Suematsu, Ph.D
Specially Appointed Professor: Takashi Shiba, Ph.D
Specially Appointed Professor: Satoshi Tsukamoto, Ph.D
Visiting Professor: Satoko Itaya, Ph.D
Visiting Associate Professor: Takashi Mehata, Ph.D
Research Fellow: Tamotsu Nishino, Ph.D

[Papers]

[1] Yuki Fujiya, Tomyuki Furichi, Donald Y. C. Lie, Noriharu Suematsu, “Effect of Input LSB/USB Signal Imbalance on a 1-bit BPDSM Using Manchester Encoding and Tripler,” IEEE Access, vol.13, pp.212794 – 212805, Dec 2025.

[2] Yuki Fujiya, Koki Edamatsu, Tomoyuki Furuichi, Takashi Shiba, Noriharu Suematsu, "Simplified Model and Its Evaluation of Wi-Fi Sensor Node Identification Method Using Wi-Fi Backscatter and Self-Mixing Receiver," IEEE Transactions on Microwave Theory and Techniques (MTT), Vol.74, no.1, pp.1110-1120, Jan. 2026

[3] Noriharu Suematsu, Tomoyuki Furuichi, Satoshi Tsukamoto, Yoshiaki Morino, Akihito Hirai, “Q/V-Band DBF Array Antenna and Direct Digital RF Transceivers for Future LEO Constellation Satellites (Invited),” 2025 Asia-Pacific Microwave Conference (APMC), Dec 2025. DOI: 10.1109/APMC65046.2025.11379249

[4] Takashi Shiba, Tomoyuki Furuichi, Noriharu Suematsu, “Multipath Signal Determination Using Stochastic Approach for Power Delay Profile of Local 5G System,” 2026 IEEE Radio and Wireless Symposium (RWS), pp.100-103, Jan 2026. DOI: 10.1109/RWS64705.2026.11408639

IT21 Center Industry-Academia-Government-Collaboration Research and Development Division, AI Hardware Security Project

Protecting security hardware from machine-learning-based physical attacks

Naofumi Homma, Professor

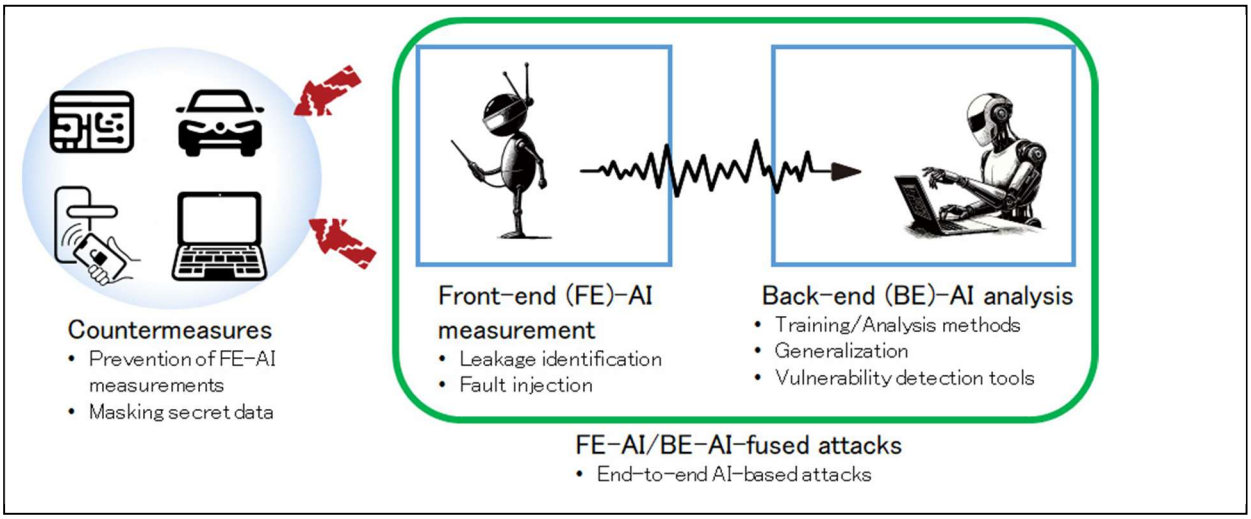


Fig. Project Overview.

[Research Target and Activities]

IT-21 Center has been promoting research and development of next-generation information communication technology (ICT) through industry-academia collaboration projects. From FY2025, we have launched a new project to promote research and development of AI-related security (AI security) with the aim of establishing highly secure ICT in a society where AI is widespread.

The main purpose of this project is the research and development of cryptographic hardware that is highly resistant and robust against various physical attacks. When assuming implementation on IoT terminals and edges, in addition to cyber-attacks, physical attacks (attacks that physically access the system and steal or tamper with information) will be a major risk. Among these, the most realistic threat is the side channel attack, which exploits unintentional physical quantities (power consumption, electromagnetic radiation, execution time, etc.) during system operations to steal secret data and control in a non-destructive and non-invasive manner.

Considering the above, this project promotes the research and development of advanced AI-based side channel attacks and their countermeasures. Specifically, we are conducting the research mainly in the industry-academia collaboration project "Development of AI hardware security technology" in the framework of the JST K Program "Establishment of AI security technology necessary for a data-driven economic society where artificial intelligence (AI) is widespread," which we were commissioned to do from FY2024.

[Staff]

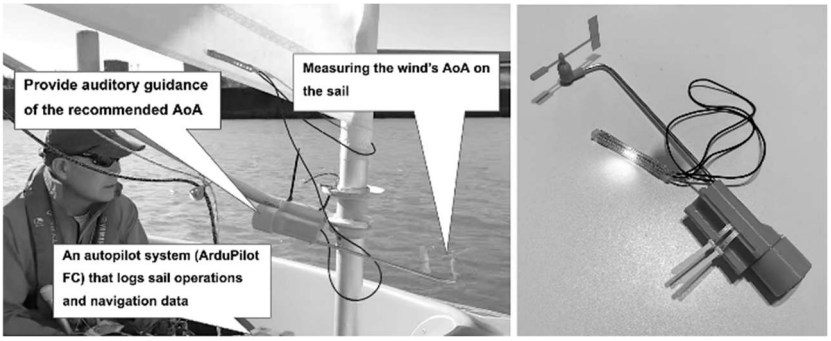
Professor: Naofumi Homma, Ph. D

[Papers]

[1] Akiko Inoue, Kazuhiko Minematsu, Rei Ueno, and Naofumi Homma, “How to Implement Authenticated Encryption on XTS-enabled Devices,” IACR Transactions on Symmetric Cryptology, Vol. 2025, No. 4, pp. 167-198, December 17, 2025.

Exploratory Research Division

Interactive Drone Content for Entertainment / Wildlife Symbiosis



Sensory Substitution Device, SoundTelltales

Yoshifumi Kitamura, Professor (Project Leader)

[Research Target and Activities]

Drones have been playing an increasingly active role in recent years, but their utilization requires consideration of sustainability and accessibility. In order to realize a symbiotic society, this study addresses the following three issues to develop key technologies for the utilization of drones that can be used by anyone by introducing an open source framework and environmentally friendly technologies. In addition to unmanned aerial vehicles (UAVs), we will also consider unmanned surface vehicles (USVs) as we conduct a broad-ranging review of drone technology.

[Achievements]

To create an environment where a diverse range of users, including those with visual impairments, can participate in sailing safely and independently, we conducted a study to reconfigure sailing techniques and support interactions from a universal design perspective, in collaboration with Dr. Koh Sueda of SENSEFOIL PTE. LTD. and Dr. Takahiro Miura of the National Institute of Advanced Industrial Science and Technology (AIST). In particular, we positioned the state of “man-boat unity”—where the boat, sailor, support staff, and environmental information complement one another—as an inclusive form of water mobility in marine sports. We explored methods to convert sailing decisions, which tend to rely on visual information, into alternative feedback such as auditory and tactile cues.

This year, we focused on SoundTelltales, a sailing assistance device for the visually impaired, and worked to systematize the design philosophy, implementation requirements, and validation methods for assistive interactions. We redesigned the wind flow indicated by the telltales on the sail not merely as a substitute for visual information, but as task-oriented auditory feedback that guides the sailor toward the next required sailing maneuver. We exchanged views with stakeholders in the field of sailability regarding the appropriate level of detail for presenting information such as wind direction and speed, sail angle of attack, and boat attitude, as well as the nature of support that does not compromise the competitive spirit, enjoyment, or autonomy of the sailors.

In terms of implementation, we improved a prototype that processes sailing condition data obtained from sensors in real time and provides auditory feedback indicating the proximity to the optimal trim and the direction of correction. In particular, to make it easier for visually impaired sailors to independently assess the quality of their sail trim, we explored a hybrid support system that combines non-verbal feedback—which does not rely on excessive verbal instructions—with minimal verbal assistance provided only when necessary. In addition, we established operational safety guidelines that issue a clear warning tone in the event of a communication failure or missing sensor data, prompting a switch to human assistance.

In terms of real-world implementation, SoundTelltales was installed on the competition boats at the 2025 National Hansa Class Blind Sailing Championship held in November 2025, allowing us to verify its usability in an environment closely resembling actual competition conditions. This enabled us to gain a concrete understanding of the installation method, the clarity of the audio, the division of roles with support staff, and operational challenges—not only through laboratory evaluations but also as an assistive technology that can be effectively deployed in the field of blind sailing.

A paper summarizing these research findings—titled “Auditory Sensory Substitution for Inclusive Sailing: Real-time Sail Trim Feedback based on Angle of Attack”—has been accepted for ICCHP 2026 and is scheduled to be presented in July 2026. This work represents an attempt to recode the implicit, physical “dialogue with the wind” inherent in sailing into a sensory modality that can be shared regardless of visual impairment.

[Papers]

[1] Sueda, K., Miura, T., et al.: Auditory Sensory Substitution for Inclusive Sailing: Real-time Sail Trim Feedback based on Angle of Attack, Proceedings of the International Conference on Computers Helping People with Special Needs (ICCHP) 2026, (accepted, to appear), July 2026.

IT21 Center
Exploratory Research Division
Wireless IoT Technology for Smart Factories

Toward smart factories with next generation wireless IoT

Noriharu Suematsu, Professor (Project Leader)
Tomoyuki Furuichi, Assistant Professor

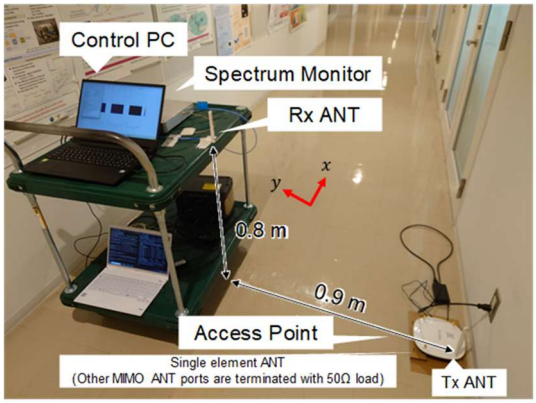


Fig.1: Multi-path fading measurement

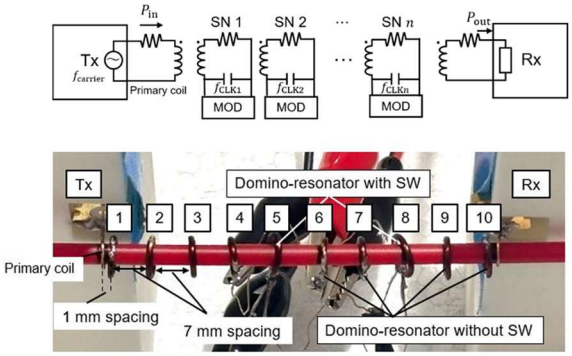


Fig.2: Wireless sensor network experiment using sub-cm domino resonators

[Research Target and Activities]

Beyond 5G(B5G)/6G will offer us not only high speed/high throughput but also low latency (real-time)/massive connection wireless IoT communication. The factories equipped with B5G/6G (i.e. smart factories) is a key of manufacturing revolution which is called as “Industry 4.0.”
This division conducts exploratory research on establishing the following two technologies.
(a) measurement and analysis of smart factory’s real-time radio environment in which multiple IoT communication systems (such as local 5G, wireless-LAN, Bluetooth and WPT) coexist.
(b) wireless sensor network for brain machine interface (BMI).

Fig.1 shows multi-path fading measurement setup in an indoor environment. We successfully demonstrated the measurement of frequency-selective fading in 2.4 GHz/ 5 GHz band overall frequency band not a single frequency in multi-path environment by using the developed real-time wideband spectrum monitor.

Fig.2 shows wireless sensor network experiment involved ASK modulation function using sub-cm domino resonators which will be integrated with sensors of high dense electroencephalography (EEG) for BMI.

[Papers]

[1] Fumiaki Wakiya, Tomoyuki Furuichi, Noriharu Suematsu, "Feasibility Study of WSN System for Wireless EEG Using Sub-cm Sized 2-GHz Domino-Resonator," IEEE IMBIOC, May2025.

[2] Tomoyuki Furuichi, Eisai Nagahari, Takashi Shiba and Noriharu Suematsu, "Multi-path Fading Measurement of 2.4 GHz/5 GHz band with Real-time Wideband Spectrum Monitor," IEEE RFIT2025, Aug. 2025.

[3] Kota Nishi, Tomoyuki Furuichi, Noriharu Suematsu, "Basic Experiment of Sub-cm Sized 2-GHz Domino-Resonator Wireless Sensor Network for High-Density EEG," APMC2025, Dec2025.

Exploratory Research Division

Highly Efficient and Secure Implementation Technology for Post-Quantum Cryptography

Naofumi Homma, Professor

[Research Target and Activities]

In recent years, as the research and development of large-scale quantum computers has become more active, there are concerns that many modern cryptographies (especially public key cryptography) may be broken. Since cryptography is used for a long time once implemented, security against quantum computers is expected to be essential for future cryptographic systems. Post-quantum cryptography (PQC) has been rapidly gaining attention in recent years as a cryptographic technology that ensures such security. In fact, the National Institute of Standards and Technology (NIST) aims to fully transition to PQC by 2035, and is formulating the first Federal Information Processing Standard (FIPS) in 2024. In Japan, the government's Cryptography Committee is closely watching the research and development trends of PQC, and it is expected that its social implementation will gradually spread in the future.

Considering the above background, this research project aims to develop a highly efficient and secure implementation technology for PQC. When assuming the implementation of PQC on IoT terminals or edges, in addition to cyber-attacks, physical attacks (attacks that physically access the system and steal secret information) pose a major risk. Among these, one of the most realistic threats is the side-channel attack, which exploits unintentional physical quantities (power consumption, electromagnetic radiation, processing time, etc.) during system operations to steal secret information and control in a non-destructive and non-invasive manner. Even for PQC, it is important to implement it with consideration for resistance to such side-channel attacks. Therefore, this research aims to develop implementation technology that combines high physical security (tamper resistance) and efficiency to solve the above issues. Specifically, through a comprehensive approach from algorithms to hardware and system implementation, we develop tamper-resistant and highly efficient software and hardware implementation technology for major PQC methods such as lattice-based, code-based, and multivariate polynomial cryptography.

[Staff]

Professor: Naofumi Homma, Ph. D

[Papers]

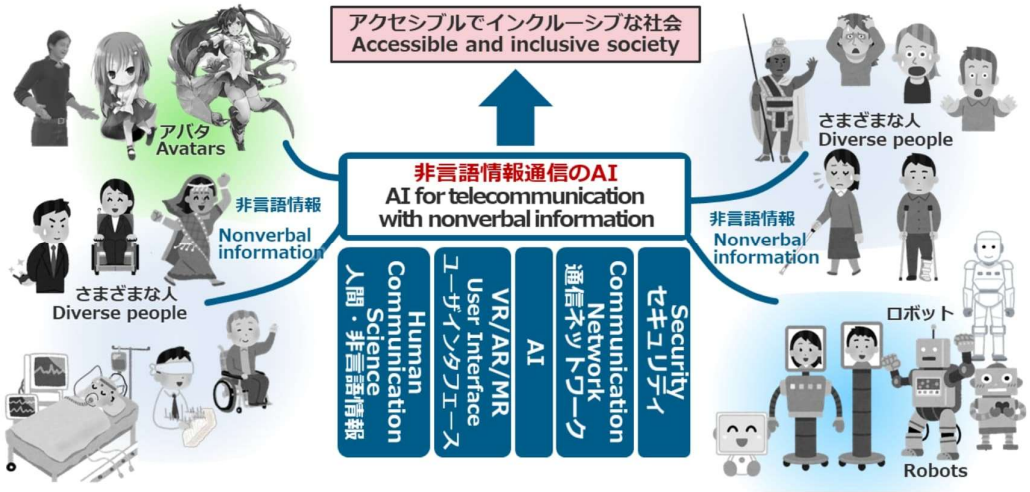
[1] Hiroshi Amagasa, Rei Ueno, and Naofumi Homma, “AVX2 Implementation of QR-UOV for Modern x86 Processors,” IACR Transactions on Cryptographic Hardware and Embedded Systems, 2025 (Accepted)

Interdisciplinary ICT Research Center for Cyber and Real Spaces

In future telecommunications, it is expected that people will be able to communicate with each other in the cyber/virtual space with objects and information from the physical/real space they are located.

The successful key to realize such rich telecommunication is to unlock “communication with nonverbal information” by appropriately conveying the subtleties of “non-spoken signals,” which plays an important role in our daily interpersonal understanding. When AI for “verbal information” has become a useful tool to transcend the barriers of language differences, we hope creating AI for “nonverbal information” to build an accessible and inclusive society that accommodates diversities in physical competences, cultures, gender, etc.

We start to conduct research and development of “telecommunication with nonverbal information” through interdisciplinary collaboration. We will synergize basic and applied AI research, networks and security, human sciences (psychology, brain sciences), human-computer interactions, and VR/AR/MR communication technologies, to impact the society with the research results.



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Interdisciplinary ICT Research Center for Cyber and Real Spaces

Enrich Telecommunication with Nonverbal Information

[Research Target and Activities]

1. Construction and Release of a Body Language Database Featuring Japanese and Taiwanese Performers

   We have constructed DIEM-A (Diverse Intercultural E-Motion Database of Asian Performers), a body motion database covering diverse cultures and emotions among Asian performers. It contains 12 types of emotional expressions, featuring over 10,000 motion capture data points from 97 professional actors (54 Japanese, 43 Taiwanese), along with scripts performed by the actors (Figure 1) [1]. As the world's first database of emotions expressed by Asian individuals, we have begun distributing it free of charge to researchers to support studies aimed at understanding emotions through movement and research on generating movements for emotionally expressive avatars.

Figure 1

Figure 2

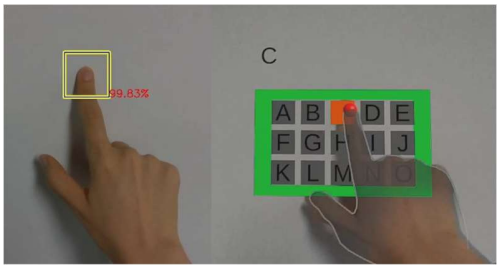


Figure 3

2. A method for efficiently rendering the circular bokeh and depth of field effects produced by camera lenses

   We developed a focused sampling method to efficiently render circular bokeh and depth-of-field effects while accounting for the characteristics of camera lenses. We demonstrated that the proposed method significantly improves the rendering efficiency of circular bokeh and depth-of-field effects compared to conventional uniform sampling and resampling methods (Figure 2) [2].

3. New Input Technology Enables AR/MR Control via Changes in Fingertip Color — Allows Walls and Desks to Be Used as Touchscreens Without Special Equipment

   Focusing on the "blanching phenomenon"—in which blood temporarily shifts away from the fingertips when they are pressed against a hard surface, causing the skin to appear white—we developed an AI model to recognize this phenomenon from camera images. By combining this with hand position data captured by the cameras standardly equipped on AR/MR devices, we were able to detect the moment the fingertips make contact and enable button operations on virtual user interfaces (Fig. 3) [3].

[Papers]

[1] Miao Cheng, Chia-huei Tseng, Ken Fujiwara, Victor Schneider, Yoshifumi Kitamura: Asian Emotional Body Movement Database: Diverse Intercultural E-Motion Database of Asian Performers (DIEM-A), Conference Proceedings of 13th International Conference on Affective Computing and Intelligent Interaction (ACII), 2025. （IEEE Xplore で公開予定）

[2] Jiawei Huang, Shaokun Zheng, Kun Xu, Yoshifumi Kitamura, Jiaping Wang Guided Lens Sampling for Efficient Monte Carlo Circle-of-Confusion Rendering, SIGGRAPH Conference Papers, Proceedings of the SIGGRAPH Conference Papers, 2025. https://doi.org/10.1145/3721238.3730608

[3] Guanghan Zhao, Yangyang Cai, Kazuyuki Fujita, Robert W. Lindeman, Yoshifumi Kitamura: BlanchTouch: Bringing Fingertip Blanch Detection into Mixed Reality for Touch Input on Flat Surfaces, Proceeding of IEEE Conference Virtual Reality and 3D User Interfaces (VR & 3DUI) , pp.294-304, March 2026. https://doi.org/10.1109/VR67842.2026.00051

Co-Creation Research Center

Furukawa Electric × Tohoku Univ.

Co-Creation Research Center for Photonics Integration

[Aims]

Our Co-Creation Research Center aims to create innovative new technologies driven by novel ideas and to develop highly specialized human resources through integration and collaboration between Furukawa Electric's materials processing capabilities and Tohoku University's comprehensive solution capabilities toward challenges in our society.

The collaboration is based mainly in the field of photonics, which plays a vital role in our future advanced information society infrastructure. Specifically, we are exploring new research frontiers and promoting joint research toward innovative new technologies with a diverse impact, such as the integration of mobility, energy, and information, which will contribute to the realization of a sustainable society where people can enjoy safe, peaceful and rewarding life.

In addition, through co-creation and collaboration between the two organizations, we will contribute to the development of human resources with advanced engineering backgrounds and the ability to practice integrative and creative thinking with different fields.

[Results in FY2025]

In order to start co-creation in the field of photonics, we held a technical conference between members of our Co-Creation Research Center and Furukawa Electric. Through these activities, we have one joint research project, one academic guidance project and one co-creation project.

Even in fields other than photonics, we were able to make a lot of opportunities for dialogue between various departments of Tohoku University and Furukawa Electric. In fiscal year 2025, a total of seven joint research projects were conducted, and the organization joined the coalition program for the utilization of NanoTerasu, the next-generation synchrotron radiation facility. Furthermore, discussions are ongoing toward the initiation of new joint research projects.

In these projects, Tohoku University and Furukawa Electric share common goals and are working to solve their respective technological and social issues. Some of these collaborative initiatives have led to four external presentations, and three press releases have been issued by Furukawa Electric.

[Staff]

Specially Appointed Professor Michihiro Shimada

Management Office for Safety and Health

Support for a safe and hygienic environment for research activities

Safety and health seminars (Webinar)

High pressure gas safety seminars (Webinar)

<Overviews of the Management Office for Safety and Health>

The Management Office for Safety and Health is an organization of the RIEC that aims to ensure the safety and health environment of faculty members, students, and staff who cooperate in the promotion of research, and to provide safety advice and cooperation so that activities can be carried out smoothly.

Specific activities include safety management guidance related to experiments, confirmation of sanitary conditions in the premises and buildings, and holding of various committees and training sessions on safety.

<Roles of the Management Office for Safety and Health >

In the safety management guidance related to experiments, since there are research activities involving the handling of hazardous chemical substances such as chemicals and high pressure gases and hazardous equipment such as X-ray equipment, we provide the guidances on the management of chemical substances and the proper operation of equipment in accordance with university regulations and internal regulations of the research institute.

In the checking the sanitary conditions in the premises and buildings, we carry out regular patrols to prevent the occurrence of any situation that could lead to an accident or incident, and distribute and replenish disinfectants to maintain a sanitary environment.

In the holding of various committees and training sessions on safety, we carry out the preparation of safety and health committees, safety and health seminars, high-pressure gas safety seminars, and so on.

<Activities of the Management Office for Safety and Health >

The main activities for this fiscal year are summarized below.

- ○ Web-based safety and health seminars for institute staff and students (442 participants).
- ○ Web-based high-pressure gas safety seminars (145 participants).
- ○ Inspecting and supporting improvements in the institute's safety and health management system and work environment.
- ○ Assisting with regular self-inspections of local exhaust ventilation systems.
- ○ Management and support of IASO.
- ○ Managing and supporting the comprehensive hazardous substance management system.
- ○ Researching safety and health-related laws and collecting information on safety and health management.
- ○ Providing advice and information to safety management personnel in each department. Coordination with other departments and regulatory agencies within the university
- ○ Providing related information via the website.
- ○ Implementing measures for infectious disease control (e.g., distributing disinfectants, providing information via the website).

[Staff]

Manager: Naofumi Homma, Professor.

Deputy Manager: Shigeo Sato, Professor.

Maho Abe, Technical Staff.

Hiroyuki Yagyu, Technical Staff.

Haruka Takahashi, Clerk.

Flexible Information System Center

Development and Management of Flexible Information System

[Summary and Role of the Flexible Information System Center]

The existing information systems are inflexible, meaning that they only provide processing functions predetermined in their design phase. The objective of this center is to introduce, operate, and maintain information networks and systems to support research activities in the Research Institute of Electronic Communication (hereafter RIEC), based on the concept of flexible information processing that reflects human intentions and the environment.

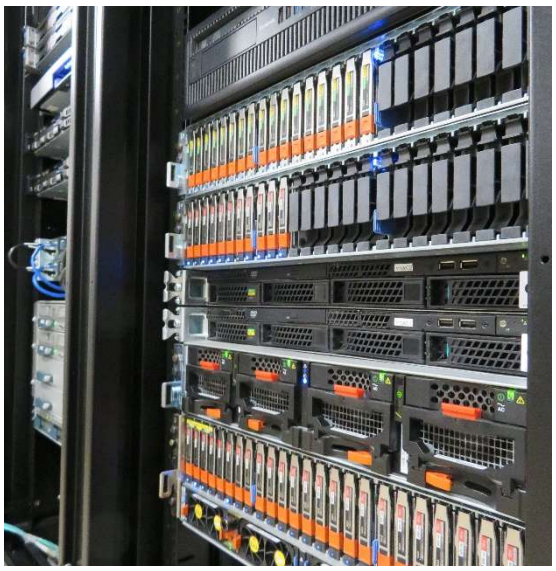


Figure RIEC server room

Moreover, utilizing know-how obtained through practical experiences of the information networks and systems, this center designs and constructs the state-of-the-art systems for advanced organization, utilization, management and operation, and dispatch of scientific information.

1. Information collection, organization, dispatching, utilization, and research support environment.
2. Advanced maintenance, management, and operation of the network.
3. Technical support for information networks and systems in the institute.

[Status Report of the Flexible Information System Center]

At the Flexible Information System Center, we manage and operate the server system and the information network underlying the academic research conducted throughout RIEC.

- Maintaining and monitoring the server and network hardware.
- Responding to information security crises.
- Advising and answering problems on the use of network services raised by individual research groups.
- Managing the information system accounts.
- Constructing and renewing the official RIEC website.
- Developing and publishing videos containing the events and conferences associated with RIEC activities.
- Establish and maintain an online conference system in the conference room, and support the operation of online events.
- Improving on the security measures of mobile devices checked out of the RIEC premises.
- Operating the system with backup power sources under scheduled power shutdowns.

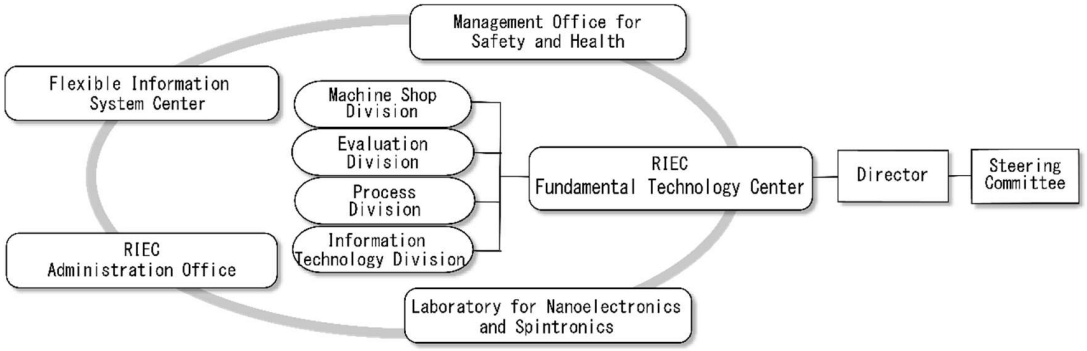
[Staff]

(1) Steering Committee
Professors: Go Hasegawa, Dr., Masafumi Shirai, Dr., Takuo Suganuma, Dr., Akio Ishiguro, Dr., Toshihiko Hirooka, Dr.

(2) Staff
Director (Professor): Go Hasegawa, Dr.
Technical Official: Kenji Ota
Technical Official*: Yuko Maruyama
Technical Support Member: Mutsumi Shuto, Hitoshi Shoji

Fundamental Technology Center

Supporting research with high-level specialized knowledge and technology



Overview of the Fundamental Technology Center

[Research Target and Activities]

The Fundamental Technology Center provides a wide range of technical support for research and development through four divisions: Machine Shop Division, Evaluation Division, Process Division, and Information Technology Division. The following is a summary of the activities of the divisions of the Fundamental Technology Center for the current year.

1. Machine Shop Division

Following requests from researchers, the Machine Shop Division supplied 92 machining products. About 16% of the requests were from outside the institute.

2. Evaluation Division

24 laboratories and 4 external research institute and company utilized the evaluation and measurement apparatuses for shared usage (the utilization time was 2,293 hours). Technical assistance on the use of liquid helium was provided for 3 laboratories. In cooperation with the administration and the management offices for safety and health, this division also engaged in safety maintenance of the institute.

3. Process Division

In cooperation with the technical office, a section of the Laboratory for Nanoelectronics and Spintronics, 450 Electron-beam lithography products, 32 photomasks and 11 commissioned analyzes such as focused ion beam processing and analysis were supplied. Operation management and maintenance were provided for operating the clean rooms of the Laboratory for Nanoelectronics and Spintronics.

4. Information Technology Division

This division operated the in-house network at the institute and maintained shared-use-information-equipment, in cooperation with the Flexible Information System Center. This division also engaged in the contracting aspects of collaborative research based on intellectual property rights and gave advice to researchers who tried to apply for the grant of patents.

[Staff]

Director (Professor): Shigeo SATO.

Technical Officials: Tamotsu SUENAGA, Kento ABE, Yasuaki MAEDA, Kana TSUKIMOTO, Maho ABE, Takenori TANNO, Hiroyuki YAGYU, Iori MORITA, Rikima ONO, Michimasa MUSHA, Yuko MARUYAMA, Kenji OHTA

Ad-hoc research groups

Taking advantage of the wide range of expertise in the institute, ad-hoc research groups are formed outside of the formal organizational structure to investigate challenging exploratory topics and needs-based, cutting-edge subjects.

[Cyber-Physical Security Research Group]

For the next-generation information and communication infrastructures such as IoT, M2M, and CPS, we aim to developing advanced information security technologies to ensure security and reliability at the level of vast and diverse information sources (i.e., embedded devices such as sensor terminals) in a vertically integrated manner by various researchers from the viewpoints of software constitutive theory, system security, hardware security, circuit architecture, next-generation microprocessor, and so on. In 2025, we continued discussion about our goal and research direction with seminars and meetings.

[Brainmorphic Nano-Devices and Circuits Research Group]

Brain-inspired hardware systems have been actively developed recently. However, a big break-through to the true brain-like system has not been reached yet. This research group aims at the development and implementation of novel brainmorphic computational hardware that reproduces the biophysics and dynamics in the brain directly through dynamics and physics of nano-devices and ultra-low-power integrated circuits based on the latest physiological knowledge. This year, Yamamoto succeeded Horio as the PI of this group, and the group has promoted research from a wide range of perspectives, including neuroscience, spintronics devices, integrated circuits, cultured neuronal networks, and nonlinear complex dynamics. For example, Hirano and Yamamoto organized the satellite workshop "Frontiers and Hardware Applications of Neural Network Models" at ICONIP2025. In addition, the Grant-in-Aid for Transformative Research Areas (A), "Multicellular Neurobiocomputing" (FY2024–2028) is currently being promoted with several members of our group serving as PIs or co-investigators of the planned research. The initiative aims to mathematically model the brain's information processing grounded in biological components and translate these models into system-level applications. Because it aligns closely with our group's mission, we anticipate a seamless research pipeline spanning the elucidation of fundamental principles through their realization in integrated circuits.

[Beyond 5G Network Technology Research Group]

For next-generation wireless communication systems, Beyond 5G (B5G), realization of the optical-wireless-converged full-coherent transmission network that seamlessly connect the optical-fiber network and terahertz wireless network is necessary. This research group aims at realization of the B5G full-coherent transmission networks in close cooperation by researchers who specialize in optical fiber communications, terahertz wireless communications, optical-wireless mutual converting devices/systems, quantum computing, and network systems. In FY2025, we discussed future directions of our collaborative research as well as to consider strategies toward obtaining large-scale fundings.

[Edge AI Semiconductor Group]

As the usefulness and application potential of AI and brain-inspired computing continue to attract growing attention, numerous challenges remain for their practical social implementation. For example, while there is increasing demand for higher performance and greater sophistication in AI processing executed on edge devices, there are also severe constraints on infrastructure costs, including power supply and installation scale. To address these issues, it is essential to integrate novel technologies encompassing computational algorithms, architectures, circuit methodologies, devices, and materials that differ fundamentally from conventional approaches. From this perspective, the group establishes opportunities for close collaboration and active exchange of ideas among researchers from diverse specialized fields, thereby promoting agile and strategic research directions toward solving these challenges.

In fiscal year 2025, in order to achieve the above objectives, preparations were made to establish a design center at the Institute (official establishment scheduled for FY2026). In addition, an international symposium was held with National Yang Ming Chiao Tung University in Taiwan (March 2026) to secure access to semiconductor fabrication lines required for design activities.

Center for Science and Innovation in Spintronics (CSIS)

＜About the Center＞

Establishment : January 30, 2018

Organization : Director: Shunsuke Fukami (Professor of RIEC)
Number of academic members: 55
(including 12 full-time, 35 concurrent and 8 guest members)

Research Target : Creation of world-leading research center pioneering in so-called "Spin-Centered Science" by strategic consolidation of excellent researchers from foreign leading universities in fundamental and applied fields.

Research Activities : Spin-centered fundamental science, advanced spintronic materials, spintronic devices, and integration technology of spintronic devices.

＜Major Achievements in 2025＞

- **Promotion of world-leading research in spintronics**

Excellent 5 proposals, which are creative and expected to make outstanding achievements, were adopted to the international cooperative research projects and their research and outsourcing expenses were supported by CSIS. The submission fees and/or article processing charges of high impact-factor journals were also supported.

- **Fostering excellent early-career researchers**

Excellent early-career researchers, 8 persons from foreign countries, were employed as full-time researchers to promote collaborations with researchers of domestic and foreign institutions. The Core Research Cluster for Spintronics Award was given to an early-career researcher who has produced outstanding academic achievement in Spintronics.

- **Promoting international academic exchange**

The laboratory for international collaboration with the University of Chicago was operated continuously. The 9th International Symposium for the Core Research Clusters for Materials Science and Spintronics was held in November 2025. Other several international meetings were also co-sponsored or supported by CSIS.

Advanced Institute for So-Go-Chi (convergence knowledge) Informatics (So-Go-Chi)

＜About the Center＞

Establishment: April 1, 2024
Granted based on research activities as an Advanced Institute of Yotta Informatics supported by MEXT from 2018 to 2023.

Organization: Director: Nobuyuki Sakai (Professor, Graduate School of Arts & Letters/RIEC)
Number of members: 53 (Graduate School of Arts & Letters, Graduate School of Education, Graduate School of Economics and Management, Graduate School of Engineering, Graduate School of Agricultural Science, Graduate School of of International Cultural Studies, Graduate School of Information Sciences, Graduate School of Life Sciences, Graduate School of Biomedical Engineering, IDAC, RIEC, IRIDeS, The Center for Academic Resources and Archives, CIES, Unprecedented-scale Data Analytics Center, Cyberscience Center, FRIS, Cognitive Neuroscience Application Center)

Research Target: To approach the social and technological problems in modern societies, we integrate human and social sciences with informatics and find solutions for the problems based on the human evaluation and emotions.

Research Activities: The amount of information is rapidly increasing and causes many social and technological problems in the modern societies. The ordinary extension of the conventional ICT cannot cope with such gigantic amount of information, therefore essential paradigm change for the information processing is needed. In this institute, we aim at the new discipline, which can manage the quality of information as well as the quantity of information. For the sake, experts of information engineering, human and social science from departments are discussing about interdisciplinary collaborating works to understand the quality and value of information, as well as the quantity. The value information is the key properties for the future informatics to receive the full benefit of the information in the upcoming “beyond the big data” era. So-Go-Chi is not only a multidisciplinary nor an integrated science. It is completely new academic activities using many kinds of technologies and knowledges on some social issues. We also aim to build up completely new academic way for solving social and technological problems in the modern societies.

＜Major Achievements in 2025＞

1. We employed four early-career informatics researchers to effectively introduce data science knowledge into collaborative research related to the human and social sciences.
2. We supported 18 multidisciplinary projects integrating the human and social sciences with informatics, which are expected to contribute to the development of new information science.
3. We organized the AI So-Go-Chi Symposium, where the achievements of the 18 projects were presented and discussed. In addition, we co-organized an invited symposium at the 89th Annual Convention of the Japanese Psychological Association titled “Artificial Intelligence (AI) as a Decision Partner: Unlocking Human–AI Collaboration for a Better Life,” as well as the HIP Research Meeting of IEICE and various other workshops.

Center for Spintronics Integrated Systems
Center for Innovative Integrated Electronic Systems (CIES)

＜About the Center＞

Establishment：The CIES was established in October 2012 to enhance industry-academia collaborations and contribute to further development of the electronics industry. The building of the CIES was constructed in March 2013 as the first Science Park in this country by a private donation located in Aobayama New Campus at Tohoku University.

Organization：Director: Tetsuo Endoh (Professor, Graduate School of Engineering)
Number of staff: 78 (including appointments across Graduate School of Engineering, Graduate School of Information Sciences, RIEC etc.)

Research Target：The CEIS researches and develops integrated electronic technologies with various research seeds that Tohoku University has and abundant results of industry-academia collaboration as centripetal force. And the CIES pursues to contribute to the enhancement of global competitiveness in the field of next generation integrated electronics systems by establishing an international industry-academia collaboration base. Further, the CIES aims for practical use of the technologies in this field and is aiming to create new industries.

Research Activities：Under the framework of industry-academia joint research, national projects, regional collaboration projects, the CIES has expanded from the world's most advanced spintronics technology, which has been developed at CIES, to AI hardware technology and power electronics technology. While promoting research and development of these three core technologies, we are aiming to develop an innovative integrated electronics system that realizes dramatic power-saving operation that is indispensable for the realization of carbon neutrality and AI / IoT / DX.

＜Major Achievements in 2025＞

CIES has managed the “CIES consortium” which consists of industry–academic collaborations, major national projects (CAO, MEXT, METI, NEDO, JSPS, JAXA) and regional collaboration projects. We have promoted the development of core technologies related to integrated electronics from material, equipment, devices and systems to include spintronics, AI hardware, and power electronics in cooperation with various international and domestic companies aiming for the practical applications of innovative core technologies created by Tohoku University. Here, these companies utilized “a special private-sector investment promotion zone system (for information service-related industries)” under a joint application from Miyagi prefecture and local municipalities, and “financial assistance according to the amount of property tax paid (created under an agreement between Tohoku University and Sendai City)”.

In 2024, our university became the first institution to be certified as an Internationally Research Excellence, committing to three principles: (1) Impact—the creation of social value that transforms the future; (2) Talent—nurturing diverse talents to shape the future; and (3) Change—governance that accelerates transformation and challenge. This center aims to contribute comprehensively to the development of innovative technologies in the semiconductor field and to the advancement of industry-academia collaboration schemes, driven by these efforts. Specifically, in addition to international industry–academia research and development activities, we

are advancing high-level human resource development in collaboration with 14 universities across Japan as a hub of the MEXT X-nics Project “Innovative spintronics X semiconductor research hub”. Furthermore, as a core institution in the UPWARDS for the Future, we have continued activities such as hosting visits from U.S. universities and delivering special lectures. Through collaboration among industry and universities in Japan and the United States, we are engaged in innovative semiconductor research and development, manufacturing, supply chains, and human resource development. In addition, the Director has participated as an advisor to the T-Seeds, working with industry, universities, colleges of technology, and governmental organizations to strengthen the foundation of Japan’s semiconductor-related industries, foster human resources, and enhance supply chain resilience. In 2025, the Tohoku University Semiconductor Creativity Hub (S-Hub) was launched to integrate and promote semiconductor education across the entire university, and the Director was appointed Head of the Global Frontier Human Resource Development Division. Through these activities, we are committed to contributing to the realization of a carbon-neutral society, sustainable economic growth and economic security, and the development of highly skilled human resources who will lead these efforts.

CIES has developed a variety of innovative technologies with world-first 300mm wafer process line and facilities operated by the university for prototype manufacturing and characterizing spintronics integrated circuits compatible with world-class companies and has made progress in developing IoT and AI systems that require ultra-low power consumption. Specifically, we have further advanced next-generation magnetic memory SOT-MRAM device technology integrated with 300 mm wafer CMOS circuits, achieving the world’s lowest power consumption for write operations, reducing write energy by 35% compared with previous levels—while maintaining ten-year data retention and ultra-high-speed write performance. This achievement establishes a clear pathway toward memory technologies that significantly reduce power consumption for AI applications. In addition, we have successfully developed a demonstration chip for edge AI utilizing CMOS/spintronics hybrid technology, confirming more than a 50-fold improvement in energy efficiency in a demonstration system. The development of an edge AI application processor chip incorporating CMOS/spintronics hybrid technology as embedded memory that serves both operating system/application boot and main memory functions is a world first. In power electronics technology, under the MEXT INNOPEL (Innovative Power Electronics Technologies) Project, we have been conducting R&D on next-generation power module technology for EV drive inverters, ultra-high-speed digital control technology, and power supply technology for high-performance data centers. Our achievement in establishing a prospect for tripling output density through the development of ultra-compact double-sided cooling power modules was highly evaluated. Based on this success, we established the Fuji Electric x Tohoku Univ. Advanced Technology Co-creation Research Center to promote research activities in power electronics and power semiconductor fields. Through this initiative, we are conducting research on high-efficiency, compact power modules and power supply and drive systems, while also exploring joint research themes aimed at creating new values that contribute to a decarbonized society. In addition, to create new value through end-to-end research activities from materials development to social implementation, we have established and launched the Sumitomo Bakelite x Tohoku Univ. Co-creation Research Center for Materials and Processes for Next-Generation Semiconductors. Furthermore, with the aim of promoting research and development of materials, components, devices, and modules that create new value in the power electronics market, we have established the Tamura

x Tohoku Univ. Advanced Power Electronics Co-creation Research Center. Utilizing the three core technologies, we aim to develop systems beneficial to AI/IoT/DX, which is indispensable for realizing carbon neutrality and requires ultra-low power consumption.

Aiming to contribute to the development of the innovative integrated electronics business and further advancement of industry-academia collaboration, Power Spin Inc., a startup company from Tohoku University, is now in its nineth year, and it has been put into practical use based on the technology and know-how of this center. The regional cooperation was expanded with cooperation of Miyagi Prefecture, Iwate Prefecture, Yamagata Prefecture, the METI Tohoku, etc.

We will continue to create innovative core technologies and contribute to the industry and the enhancement of global competitiveness by the practical applications, and “new creation and innovation” through global and regional partnership.

Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan
WISE Program
(Doctoral Program for World-leading Innovative & Smart Education)
Advanced Graduate Program for AI Electronics

＜About the Center＞

Establishment：Adopted October, 2018.
It has been adopted by the WISE Program (Doctoral Program for World-leading Innovative & Smart Education) of MEXT. This program is a new education program that starts from FY 2018.

Organization：Chief executive: Teiji Tominaga (President of Tohoku University)
Program leader: Masahiro Yamaguchi (Vise-President of Tohoku University (Education Reform / International Strategy))
Program coordinator: Toshiro Kaneko (School of engineering, Professor)
Program manager: Approximately 70 people (including managers and a coordinator)

Target of Program：In this Graduate School Program, we will foster world-class talented doctors who can make an innovation continuously through the learning of “an practical ability”, “solving of social problems”, “creation of novel value”, and “an ability that can see real space and cyberspace in Society 5.0 with wide perspectives”.

＜Major Achievements in 2025＞

In FY2025, 15 students completed the 5-year integrated education curriculum of the AIE-WISE program for AI Electronics. The Project Based Learning (PBL) courses, which are unique to the AIE-WISE program, were delivered in a face-to-face format in FY2025. After the end of the course, a symposium was held in which students presentated on the results of their studies in the course. In addition, four AIE lectures and an international symposium were held, in which prominent professors from Japan and abroad gave lectures on a wide range of topics, from basic technologies to applications and issues in the social practice of artificial intelligence electronics. Students in the program presented their research in English at the international symposium. We recruited and selected students for the eighth year, and 10 new students (9 new M1 students and 1 new D1 students) were selected.

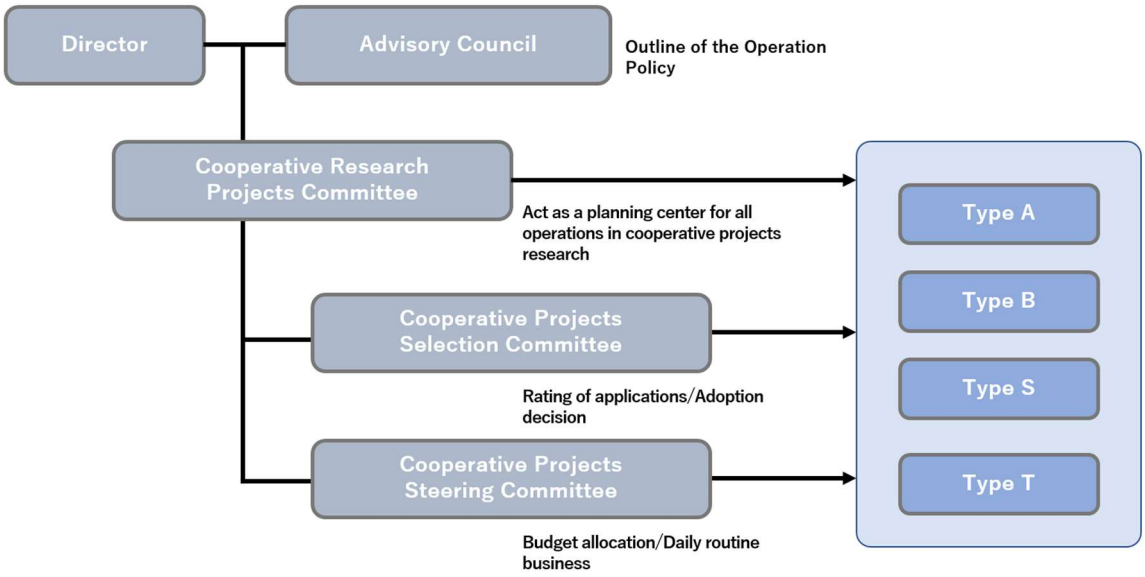
4. Cooperative Research Projects

The Institute has a long history of fundamental contributions in many fields of engineering and science that include the fields of semiconductor materials and devices, magnetic recording, optical communication, electromagnetic technology, wireless communication, applications of ultrasonic communication and acoustic communication, non-linear physics and engineering, and computer software. On the basis of this rich historical background the Institute was designated as a National Center for Cooperative Research in 1994. Accompanying Tohoku University's transformation to "a national university juridical entity" in April, 2004, this institution plays a leading role on the world stage, as its researchers, both domestic and foreign, continue the task of "investigating the theory and application of universal science and technology to realize communication, to the enrichment of humanity."

With this background, the Institute organizes Cooperative Research Projects by coordinating its activities with research workers. The main themes for Cooperative Research are selected annually by the Committee for Cooperative Research Projects. Then invitations for project proposals and participation are extended to university faculties and government laboratories as well as industrial research groups. Each project approved by the Faculty Council of the Institute is carried out by a team of researchers that include members of the Institute as well as outside participants.

The Advisory Council which includes members from other institutions has an advisory function to the Director in defining the general direction of the research at the Institute and its Cooperative Research Projects.

The Project Selection Committee that includes members from outside of Tohoku University has a Judging function for project proposals. The purpose of the Project Steering Committee is the proper operation of approved projects.



Cooperative Research Projects List 2025

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R05/A02	Development of Fundamental Technology of Materials and Processes for New Group-IV Semiconductor Nanoelectronics	**SAKURABA Masao**	**SAKURABA Masao**
R05/A04	Development of intraluminal NMR probe for high magnetic field MRI	**MATSUNAGA Tadao**	**SUEMATSU Noriharu**
R05/A05	Fundamental Survey on Measurement of Intraoral Bite Force Using Inverse Magnetostrictive and Magneto-Optical Effects	**ISOGAI Ryosuke**	**GOTO Taichi**
R05/A07	Japan-Russia International collaborative research of new designs of high-power large-area photoconductive antenna-emitters	**DMITRY Ponomarev**	**SATOU Akira**
R05/A08	Investigation of physical structure model of high-k/Ge interface affected by process temperatures	**OTANI Yohei**	**SAKURABA Masao**
R05/A11	Survey of over100GHz direct digital transceiver technology	**SUEMATSU Noriharu**	**SUEMATSU Noriharu**
R05/A12	Study on optimization design of milli-meter wave devices and transmission lines	**ITOH Keiichi**	**SUEMATSU Noriharu**
R05/A13	New generation of 2d material based devices for terahertz technology	**MEZIANI Yahya Moubarak**	**SATOU Akira**
R05/A16	Research on dynamic VR/AR workspaces for inducing physical movements	**TAKAHARA Ryo**	**KAZUYUKI Fujita**
R05/A18	Constructive analysis of brain computing based on multicellular networks	**TANII Takashi**	**YAMAMOTO Hideaki**
R05/A19	Expansion of nonlinear complex systems theory to spatiotemporal systems and its applications	**HORIO Yoshihiko**	**SATO Shigeo**
R05/A21	New development of multicellular neurobiocomputing	**KAMIYA Haruyuki**	**YAMAMOTO Hideaki**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R05/A24	Research on Autopoietic Service Platform Supporting Smart Society	**KITAGATA Gen**	**HASEGAWA Go**
R05/A29	Fabrication of magnetic garnet ultrafine particles for flexible magneto-optical films	**HASHIMOTO Ryosuke**	**GOTO Taichi**
R05/A30	Research of photonics/electronics-heterogeneous integration technology	**KITA Tomohiro**	**SATOU Akira**
R05/A31	Discovering a relationship between auditory attention and auditory immersion	**KIM Sungyoung**	**SAKAMOTO Shuichi**
R05/A33	Emotion processing in real and cyber world	**Monica Perusquia Hernandez**	**CHENG Miao**
R05/A35	Development of automated sound environment recognition system with decentralized autonomous organization type structure	**TAKANE Shouichi**	**SAKAMOTO Shuichi**
R06/A01	Development of novel semiconductor quantum devices with atomically thin layered materials	**KATO Toshiaki**	**OTSUKA Tomohiro**
R06/A02	Study on resistance of quantum devices to radioactive radiations	**KISHIMOTO Yasuhiro**	**OTSUKA Tomohiro**
R06/A03	Integrated Devices using Memristor and Capacitor and Spike Neurosystem using Transient-type Signal Transfer	**KIMURA Mutsumi**	**SATO Shigeo**
R06/A04	Physics and applications of single nanocrystal transistors	**SHIBATA Kenji**	**OTSUKA Tomohiro**
R06/A05	Electronic transport properties of quantum nano-devices based on two-dimensional materials	**HARA Masahiro**	**OTSUKA Tomohiro**
R06/A06	Realization of monolithic three-dimensional stacked devices composed of single-crystalline silicon/polycrystalline germanium tin	**YAMAMOTO Keisuke**	**SAKURABA Masao**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R06/A07	Realzaition of the transistor miniaturized down to monomolecule scale	**FUKIDOME Hirokazu**	**FUKIDOME Hirokazu**
R06/A08	System Applications of Neuromorphic Edge Computing Hardware	**SATO Shigeo**	**SATO Shigeo**
R06/A10	Cross-Reality Collaboration with Digital Twins	**Bernd Froehlich**	**KITAMURA Yoshifumi**
R06/A11	Element number reduction of embedded millimeter-wave large-scale array antennas by utilizing a combination of mixed element number subarrays	**Satoshi Yoshida**	**SUEMATSU Noriharu**
R06/A12	Delay-Bounding Congestion Control Algorithm under Internet Traffic	**UTSUMI Satoshi**	**HASEGAWA Go**
R06/A13	Research on hardware security using machine learning	**OGUMA Hiroshi**	**HOMMA Naofumi**
R06/A14	A Study on Congestion Control Based on Artificial Intelligence Technology for Wireless Network	**OBATA Hiroyasu**	**HASEGAWA Go**
R06/A15	Development of measurement system for spin-wave detection using magnetic garnet waveguide	**SHIRAKI Eiji**	**GOTO Taichi**
R06/A16	Simultaneous Wireless Power Transfer to Multiple IoT Devices Using Director Elements and Metamaterials, with Applications in Underwater and Maritime Environments	**MARUYAMA Tamami**	**SUEMATSU Noriharu**
R06/A17	Augmented Reality for Human-Robot Interaction	**SUZUKI Ryo**	**KITAMURA Yoshifumi**
R06/A18	Research on remote sensing technology for crustal deformation using optical fiber networks	**KASAI Keisuke**	**KASAI Keisuke**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R06/A19	Cross-Cultural Dialogue on the Potential of the Sense of Smell	**OBRIST Marianna**	**TSENG Chia-huei**
R06/A20	Establishing Databases of Verbal and Nonverbal Features of Human Emotions	**Yang Lee-Xieng**	**TSENG Chia-huei**
R06/A22	Adaptive Avatar and Smart Telepresence Robot to enhance Remote Collaboration	**TEO Theophilus**	**CHENG Miao**
R06/A23	Age-related changes in peripersonal space during self-motion	**TERAMOTO Wataru**	**SAKAMOTO Shuichi**
R06/A24	Psychophysical properties of body expression perception: Signal efficiency and noise tolerance	**CHEN Chien-Chung**	**TSENG Chia-huei**
R06/A25	Toward comprehensive understanding of Alice in Wonderland syndrome	**TAKAGI Gen**	**SAITO Godai**
R06/A26	Creation of Bio-Devices Utilizing Short-Lived Reactive Species Synthesized by Non-Equilibrium Plasmas	**KANEKO Toshiro**	**HIRANO Ayumi**
R06/A27	Development of Printed Conductive Materials for Next-Gen Interactive Devices and Applications	**TAKADA Ryosuke**	**KAZUYUKI Fujita**
R06/A28	How do we recognize our body as overweight? Combining VR technique and psychophysiological fMRI experiments	**Hamamoto Yumi**	**KITAMURA Yoshifumi**
R06/A29	Research on synthesis method of emergency evacuation speech for overcome normality bias""	**CUI Zhenglie**	**SAKAMOTO Shuichi**
R06/A30	Psychophysical study on visual consciousness using sensory entrainment technique	**TAKESHIMA Yasuhiro**	**SAITO Godai**
R06/A31	Development of network and agent technologies to realize a super smart society	**UCHIYA Takahiro**	**SAKAMOTO Shuichi**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R06/A32	Study on Automatic Multipoint Measurement of Head-related Transfer Function	**MORIKAWA Daisuke**	**SAKAMOTO Shuichi**
R06/A33	An investigation on spatio-temporal characteristics of auditory selective attention in depth	**TERAOKA Ryo**	**SAKAMOTO Shuichi**
R06/A36	Next Generation Architecture for 6G Mobile Networks	**ABE Shuya**	**HASEGAWA Go**
R06/A37	High Efficiency and Low Loss Contactless Power Transmission System in Seawater	**INAMORI Mamiko**	**SUEMATSU Noriharu**
R06/A38	Investigation of the characteristics of audiovisual attention	**YAMAMOTO Kosuke**	**SAITO Godai**
2025A01	Local-area magnetization precession control by DC spin-orbit torque	**KODA Tetsunori**	**ISHIYAMA Kazushi**
2025A02	Emergent spin-orbit torques in 2D all van der Waals heterostructures for quantum spin-orbitronics	**DUTTAGUPTA SAMIK**	**FUKAMI Shunsuke**
2025A03	Research on automatic control and optimization for the development of large-scale quantum technology	**FUKUHARA Takeshi**	**OTSUKA Tomohiro**
2025A04	Development of magnetic garnets for ultrafast optical computing systems	**NAKAMURA Yuichi**	**GOTO Taichi**
2025A05	Algebra and Geometry of Lambda Calculus	**IGARASHI Atsushi**	**NAKANO Keisuke**
2025A06	Experimental and theoretical understanding of microwave losses in superconducting resonators	**NARUSE Masato**	**SATO Shigeo**
2025A07	Exploring the spintronic potential of novel high-entropy alloys with excellent mechanical properties: a pathway merging engineering and physics	**DUTTAGUPTA SAMIK**	**FUKAMI Shunsuke**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
2025A08	Construction and Optimization of Multi-modal XR Interaction Ecosystem: From Gaze-Pinch Enhancement to AI-driven Adaptive Interface	**LIANG Hai-Ning**	**KITAMURA Yoshifumi**
2025A09	Analysis of online text using machine learning	**ZABIR Salahuddin Muhammad Salim**	**HASEGAWA Go**
2025A10	Beyond CFET advanced interfacial analysis of integration of atomic layer devices for information communication	**NAGAMURA Naoka**	**FUKIDOME Hirokazu**
2025A11	Enhancing the Reliability of Deep Space Communications by Leveraging the Doppler and Delay Robustness of OTFS Modulation and the Interference Resistance of FHSS	**MIYAKE Masataka**	**SUEMATSU Noriharu**
2025A12	Propagation characteristics for millimeter-wave wireless body area network	**AKIMOTO Kohei**	**SUEMATSU Noriharu**
2025A13	Channel Modeling and Beamforming for Millimeter-Wave and Terahertz Communications	**XIA Sijie**	**SUEMATSU Noriharu**
2025A14	Management and performance evaluation of 5G systems.	**Pedroso Cainelli/Gustavo**	**SUEMATSU Noriharu**
2025A15	Basic research to improve the performance of high-frequency diamond transistors	**KANEKO Junichi H**	**SUEMATSU Noriharu**
2025A16	Study on optoelectronic nanodevices integrated with two-dimensional materials	**UCHINO Takashi**	**SATOU Akira**
2025A17	Deciphering the Operational Limits of Power Semiconductor Devices Through Nanoscale Observations	**SATOH Nobuo**	**YAMASUE Kohei**
2025A18	Individual differences of visual imagery and its measurement in aphantasia	**TAKAHASHI Junichi**	**SAITO Godai**
2025A19	Characterization of Polycrystalline Microstructures and Properties of High Performance Soft Magnetic Alloys	**SUZUKI Shigeru**	**ISHIYAMA Kazushi**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
2025A20	Next-Generation Remote Education Pioneered by Generative AI, XR, and the Metaverse	**HAYASHI Masako**	**KITAMURA Yoshifumi**
2025A21	Distance perception of sound around the body and its cognitive influences	**YAMASAKI Daiki**	**SAITO Godai**
2025A22	DEEM: International Collaboration Project on Annotation of the Dynamics of Emotionally Expressive movement (DEEM) Using Laban Effort Shape and Prosodic Theory	**Asaf Bachrach**	**TSENG Chia-huei**
2025A23	Large Language Model-Powered Virtual Assistants for In-situ Secondary Language Acquisition	**ORLOSKY Jason**	**KITAMURA Yoshifumi**
2025A24	Pre-verbal infant sleep and social-cognitive development	**LAU Esther**	**TSENG Chia-huei**
2025A25	Multimodal Multilingual Affective Computing: Database and Algorithms	**LEE/CHI-CHUN**	**CHENG Miao**
2025A26	The effects of embodiment of sounds on human cognitive information processing	**KITAGAWA Norimichi**	**SAKAMOTO Shuichi**
2025A27	Spintronic practical devices and emergent phenomena using sustainable materials	**SHINJI Isogami**	**SHIRAI Masafumi**
2025A28	Development of the ion beam sputter deposition system for improving the efficiency of creating magnetic oxide crystal film	**NISHIHARA Takayoshi**	**GOTO Taichi**
2025A29	Development of novel soft magnetic materials and their high-frequency magnetic properties for next generation power electronics	**AJIA Saijian**	**ISHIYAMA Kazushi**
2025A30	Study on selective dry etching of epitaxially grown SiGe and Si for Si-nanosheet fabrication	**MAKIHARA Katsunori**	**SAKURABA Masao**
2025A31	Telepresence with a Swarm of Environmental Robots for Expressing Human Embodiment	**TAKASHIMA Kazuki**	**KAZUYUKI Fujita**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R05/B01	Design of Borderless Wireless Networks for Digital Twin Society	**SATO Koya**	**SUEMATSU Noriharu**
R05/B02	Integrated Design of Wireless Communication System and Hardware in the Massive Connect IoT Era	**KAMEDA Suguru**	**SUEMATSU Noriharu**
R05/B03	Highly Functional Coherent Communication and Measurement Systems Integrating Lightwave and Microwave	**INOUE Takashi**	**HIROOKA Toshihiko**
R05/B04	Millimeter-wave and Terahertz Wave Technologies and Applications for 6G System	**SANADA Atsushi**	**SUEMATSU Noriharu**
R05/B08	Study of methods for guiding a flock of crows	**TSUKAHARA Naoki**	**KITAMURA Yoshifumi**
R05/B13	Theoretical study of memory and learning in neural networks	**IKEGUCHI Tohru**	**SATO Shigeo**
R05/B15	Research on fundamental technologies related to human and social sensing and intervention	**ARAKAWA Yutaka**	**HASEGAWA Go**
R05/B16	Study on applications using head-gaze tracking technique with a smartphone	**KAZUYUKI Fujita**	**KAZUYUKI Fujita**
R05/B17	International Research Collaboration of Brainware-LSI-Oriented Emerging Circuits/Systems	**HANYU Takahiro**	**HANYU Takahiro**
R06/B01	Development of experimental and computational systems via novel orbital magnetism	**OKABAYASHI Jun**	**SHIRAI Masafumi**
R06/B02	Empirical Study on the Applicability of Nonlinear Dynamical Theory to Various Optimization Problems	**KIMURA Takayuki**	**SATO Shigeo**
R06/B03	Quantum Circuits Accelerator based on Stochastic Computing	**Lukac Martin**	**ONIZAWA Naoya**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R06/B04	Research on mode on light	**HAMAMOTO Kiichi**	**KASAI Keisuke**
R06/B06	Conduct meetings on quality estimation and stabilization methods for satellite constellations	**KASHIWAZAKI Hiroki**	**HASEGAWA Go**
R06/B07	Exploration of New Research Area on Electromagnetic Wave Engineering	**KONNO Keisuke**	**SUEMATSU Noriharu**
R06/B08	Networking Technology for 6G Communication	**OBATA Hiroyasu**	**HASEGAWA Go**
R06/B09	Sinultaneous transmission of power and data by load-independent magnetic resonance power transfer systems	**SEKIYA Hiroo**	**SATO Shigeo**
R06/B10	Evaluation and improvement of intellectual productivity by computer	**ITOH Yuichi**	**KAZUYUKI Fujita**
R06/B11	Understanding perceptual, motor, cognitive and emotional properties of humans as the basis of communication	**TSUTSUI Ken-Ichiro**	**SAKAMOTO Shuichi**
R06/B12	An analysis framework based on the complex network theory for cross-language text analysis	**SHIMADA Yutaka**	**SATO Shigeo**
R06/B13	Development and Societal Implementation of Life Science Infrastructure Based on Ubiquitous Computing Technology	**OHNISHI Ayumi**	**HASEGAWA Go**
R06/B14	Research on representation learning in deep learning	**JINNO Kenya**	**SATO Shigeo**
R06/B15	New Developments in Human-Workspace Interaction	**KAZUYUKI Fujita**	**KAZUYUKI Fujita**
R06/B16	Self-motion perception as a multi-sensory integration process	**SAKURAI Kenzo**	**SAKAMOTO Shuichi**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R06/B19	Approximate Search Method by Random Forest for Binarized Convolutional Neural Network Models and Its FPGA Implementation	**SAITO Hiroshi**	**HANYU Takahiro**
R06/B20	Research on Stochastic Computing Algorithms	**KOSHITA Shunsuke**	**ONIZAWA Naoya**
2025B01	A nonvolatile FPGA emulator and its application to IoT	**DAISUKE Suzuki**	**HANYU Takahiro**
2025B02	Integrating Quantum Technology and Materials Science for Next-Generation Device Innovation	**MATSUNO Jobu**	**FUKAMI Shunsuke**
2025B03	Integrated Approach of Reinforcement Learning and Game Theory for Microgrid Networking	**SHAO Xun**	**HASEGAWA Go**
2025B04	Reducing Perceptual and Physical Fatigue in Virtual Reality	**Tag Benjamin**	**KITAMURA Yoshifumi**
2025B05	High-dimensional neural-network information processing based on geometric algebra	**HIROSE Akira**	**SATO Shigeo**
2025B06	Research on Enriched Multimedia through Cyber-Physical Convergence	**SONODA Kotaro**	**SAKAMOTO Shuichi**
2025B07	The Interaction Study Group for Human-Boat Unity and Sailing for Everyone	**SUEDA Koh**	**KITAMURA Yoshifumi**
2025B08	Study group for Inclusive TANKYU STEAM Programs Utilizing Nature and Open Source	**SUEDA Koh**	**KITAMURA Yoshifumi**
2025B09	Development and control of artificial cell membrane systems for measuring membrane protein functions based on surface microfabrication and nanomaterial functions	**TERO Ryugo**	**HIRANO Ayumi**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
2025T05	**Technical committee for system control** Theory and applications of system control	**WATANABE Takashi**	**ISHIGURO Akio**
2025T06	**Research presentation on theory and applications of system control** Next generation biodevices based on nano-bio hybrid systems	**HIRANO Ayumi**	**HIRANO Ayumi**
2025T07	**Spinics Research Society** Development of Magnetic Materials, Magnetic Measurements, and Magnetic Device Applications	**ENDO Yasushi**	**ISHIYAMA Kazushi**
2025T08	**New Paradigm Computing Research Group** Research and development of new paradigm computing technologies for the AI era	**HOMMA Naofumi**	**HOMMA Naofumi**
2025T09	**Technical committee for ultrasonic electronics** Research Presentations and Discussions on the Fundamentals and Applications of Ultrasonic Technology	**YOSHIZAWA Shin**	**SAKAMOTO Shuichi**
2025T10	**Brainware Research Project** Reverse-engineering adaptive information processing of animals	**ISHIGURO Akio**	**ISHIGURO Akio**
2025T11	**Study Group on Nanoelectronics and Spintronics** Development of next-generation information and communication technology based on nanoelectronics and spintronics	**SATO Shigeo**	**FUKAMI Shunsuke**
2025T12	**EMC Sendai seminarc** Seminar on Fundamentals and Applications of Electromagnetic Compatibility	**MUROGA Sho**	**ISHIYAMA Kazushi**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
2025B10	Study on Object Recognition by multi-modal sensation and perception	**KURIKI Ichiro**	**SAKAMOTO Shuichi**
R05/S01	Establishment for innovative coherent wave technology and its applications	**AOKI Toru**	**HIROOKA Toshihiko**
R06/SI01	AI & Communication Technology Based on Human-Centered Science and Its Hardware Implementation	**Su-Ling Yeh**	**HANYU Takahiro**
R06/SI02	Improving Immersive Telecommunication by Increasing Comfort in Virtual Reality	**Robert W. LINDEMAN**	**KITAMURA Yoshifumi**
R06/SI03	Support Nonverbal Communication with XR	**Bruce Thomas**	**KITAMURA Yoshifumi**
R06/T01	**Spintronics and CMOS Brain-inspired Circuit Research Group** Bridging Spintronics and Computing-in-memory Technologies for the Development of Energy-efficient Neuromorphic Processors	**ENDOH Tetsuo**	**HANYU Takahiro**
2025T01	**Electromagnetic-Wave Transmission Technologies Workshop** Electromagnetic- and light-wave transmission technologies toward 6G	**QIANG Chen**	**KASAI Keisuke**
2025T02	**Technical committee for acoustic engineering** Research presentations on advanced acoustic and speech communication systems based on a deep understanding of human auditory information processing	**SAKAMOTO Shuichi**	**SAKAMOTO Shuichi**
2025T03	**Tohoku Plasma Forum** Physics and material-bio applications of non-equilibrium plasma	**KANEKO Toshiro**	**HIRANO Ayumi**
2025T04	**Special Interest Group on Computer Science** Computer Science around Programming Language Theory and its Applications	**SUMII Eijiro**	**NAKANO Keisuke**

5. Symposium Organized by the Institute

This Symposium is planned to exchange relevant information on current important topics concerning Electrical Eng., Electrical Communications, Electronic Eng., and Information Eng. Many related researchers inside and outside Tohoku University participate the Symposium and stimulate discussion.

International symposium organized by the Institute (Symposiums held in FY2025)

No	Title	Date
134	The 14th RIEC International Symposium on Brain Functions and Brain Computer	Feb. 27-28,2026
135	11th CIES Technology Forum	Mar. 23-24,2026

6. International Activities

Many of the staff in RIEC contribute to the development of technology and science in the world by serving as editors of referees of international journals or by chairing or programming international conferences. In some fields in electronics, electrical communications, or information engineering RIEC serves as a Center of Excellence (COE), which attracts researchers and students from all over the world every year. Several academic exchange programs with foreign colleges or institutes are in operation.

International Academic Exchange Programs

- University of California (U.S.A.)
- The University of Sydney (Australia)
- Purdue University (U.S.A.)
- National University of Singapore (Singapore)
- National Taiwan University (Taiwan)
- Swiss Federal Institute of Technology, Lausanne (Swiss)
- National Chung Cheng University (Taiwan)
- National Cheng Kung University (Taiwan)
- National Yang Ming Chiao Tung University (Taiwan)
- The Technische Universität Dresden (Germany)
- University of Waterloo (Canada)
- University of California, Santa Barbara (U.S.A.)
- University of California, Barkeley (U.S.A.)
- University of Ottawa (Canada)
- Berlin Institute of Technology (Germany)
- National Tsing Hua University (Taiwan)
- Swiss Federal Institute of Technology in Zurich (Swiss)
- Technische Universität München (Germany)
- The University of Kaiserslautern (Germany)
- Johannes Gutenberg University of Mainz (Germany)
- King Mongkut's University of Technology Thonburi (Thailand)
- Chemnitz University of Technology (Germany)
- University College London, UCL (U.K.)
- The University of Melbourne (Australia)
- University of Regensburg (Germany)
- Carl von Ossietzky University of Oldenburg (Germany)
- Rice University (U.S.A.)
- University of Lorraine (France)
- University of Salamanca (Spain)
- The University of Hong Kong (China)
- Nanyang Technological University (Singapore)
- St. Petersburg Electrotechnical University (Russia)
- Paris-Saclay University (France)
- University of Warsaw (Poland)
- Polish Academy of Sciences (Poland)
- McGill University (Canada)
- Institute of Physics, Polish Academy of Sciences (Poland)
- IHP GmbH-Leibniz Institute for High Performance Microelectronics / Leibniz-Institut für innovative Mikroelektronik (Germany)
- The Interdisciplinary Center on Nanoscience of Marseille, National Center of Scientific Research (France)
- Institute of Semiconductors, Chinese Academy of Sciences (China)
- WINLAB (Wireless Information Network Laboratory), Rutgers University (U.S.A.)
- Research and Educational Center "Photonics and Infrared Technology" and Institute of Radio Electronics and Laser Technology, Bauman Moscow State Technical University(BMSTU) (Russia)

- Telecom Paris, Institut Polytechnique de Paris (France)
- Center for Artificial Intelligence and Advanced Robotics, National Taiwan University (Taiwan)
- V.G. Mokerov Institute of Ultra High Frequency Semiconductor Electronics of the Russian Academy of Sciences, and Prokhorov General Physics Institute of the Russian Academy of Sciences (Russia)

International journals in which a staff in RIEC participates as an editor

1	Applied Physics Express (APEX)
2	Auditory Perception & Cognition
3	Bioinspiration & Biomimetics
4	e-Jornal of Surface Science and Nanotechnology
5	Frontiers in Physics
6	Frontiers in Psychology
7	Frontiers in Robotics and AI
8	ICT Express
9	IEICE Transactions on Communications
10	IEICE Transactions on Electronics Special Section on Microwave and Millimeter-Wave Technologies
11	IEEE Transactions on Magnetics
12	Japanese Journal of Applied Physics (JJAP)
13	Journal of Cryptographic Engineering
15	Journal of Physics D: Applied Physics
16	MDPI Magnetochemistry
17	Science and Technology of Advanced Materials
18	Scientific Reports
19	Spin

Recent international conferences programmed by staff in RIEC

1	ACSIN-16/ICSPM-34
2	ALC2024
3	ASIACRYPT 2025
4	ASIACRYPT 2026
5	COSADE 2024
6	DATA2025
7	EM-NANO2025
8	IEEE HPSR 2025
9	IEEE ICCCN 2025
10	IEICE ICETC 2024
11	IEEE International Symposium on Radio-Frequency Integration Technology (RFIT)
12	IEEE WCCI 2024
13	Intermag 2024
14	International Conference on Magnetism (ICM) 2024
15	ISMVL 2025
16	JSAP M&BE11
17	KJF-ICOME2025
18	Magnetics and Optics Research International Symposium (MORIS 2024)
19	The 8th International Symposium on Swarm Behavior and Bio-inspired Robotics 2024
20	The Magnetic Recording Conference (TMRC) 2024
21	Western Pacific Commission for Acoustics

7. Periodicals Published by the Institute

The Institute publishes the following two periodicals to inform readers on recent research results of the Institute.

1. The Record of Electrical and Communication Engineering Conversazione Tohoku University

This journal aims at providing an opportunity to publish research results of the Institute as well as the result of the Graduate Schools of Engineering, Information Sciences, Biomedical Engineering. Since the journal also aims at publishing general research activities of the Institute and of the Graduate Schools such as records of the final lectures of retiring professors, records of the Institute Symposium, and reviews.

The name of the Journal `Conversazione´ is attributable to the `Tuesday Conversazione´ at the Department of Electrical Engineering, which had been held once a week on Tuesday since around 1920. Minutes of the meetings had been distributed to researchers outside of the University via various routes and therefore some of them had been referred to as `Records of Tuesday Electrical Engineering Conversazione Tohoku University´ with the result that they came to be treated as official publications. Though the meeting was once interrupted by World War Two, it was restarted in 1947. In 1952, the publication of the records was succeeded by the Institute and the records have been published as periodicals, two times a year recently, since No. 1 Vol. 21 was published in July, 1952.

2. The Annual Report of Research Activity at the Research Institute of Electrical Communication, Tohoku University

Published annually since 1995. This report details the activities of each research division and research facility. Also included are reports on nation-wide cooperative research projects, international symposium, and the reports and evaluation on the RIEC advisory board members. English version is also available since 2007.

3. RIEC News

As a part of RIEC's publication service, "RIEC News" was published.

With the 75th anniversary of the establishment of RIEC, RIEC News introduced cutting-edge's research and the vision of the future from RIEC's contributions to the progression of science and technology in Japan. RIEC News was first launched in March 2011. Every issue featured special topics such as large-scale projects and Specially-Promoted Research, etc. RIEC News also included information about each laboratory and center, all kinds of RIEC events, research exchange meetings, laboratories open to the public (RIEC Open Day), etc. English version was also launched in March 2014. Further, an electronic version of every issue published so far can be downloaded by following the link below.

http://www.riec.tohoku.ac.jp/riecnews/

With the 26th issue of RIEC News, it has finished multi-monthly publication style as before. From April 2020, in order to bring you the latest research results and event information as quickly as possible, RIEC News was renewed to a new web-based publication style. The new RIEC Newsweb was published by the following link.

http://www.riec.tohoku.ac.jp/riecpr/

From 2024, we shifted the publicity activity from Web-based style to SNS-based style.

8. Staff, Budget

1. Faculty & Staff

as of May 1, 2025

Professors	18
Associate Professors	18
Assistant Professors	8
Specially Appointed Professors	3
Specially Appointed Associate Professors	0
Specially Appointed Assistant Professors	4
Specially Appointed Research Fellows	8
Research Fellows	7
Administrative Staff（Including Limited Regular Employees）	31
Technical Staff（Including Limited Regular Employees）	14
Total	111

2. Researchers (FY2025)

Foreign Researchers	Visiting Professors	3
	Visiting Associate Professors	1
Cooperative Researchers of Private Company etc		5
JSPS Research Fellowship for Young Scientists		10
JSPS Postdoctral Fellowship for Overseas Researchers		2
Invitation Fellowship for Research in Japan		0
Contract Researchers		2
Contract Trainees		0
Total		23

3. Students

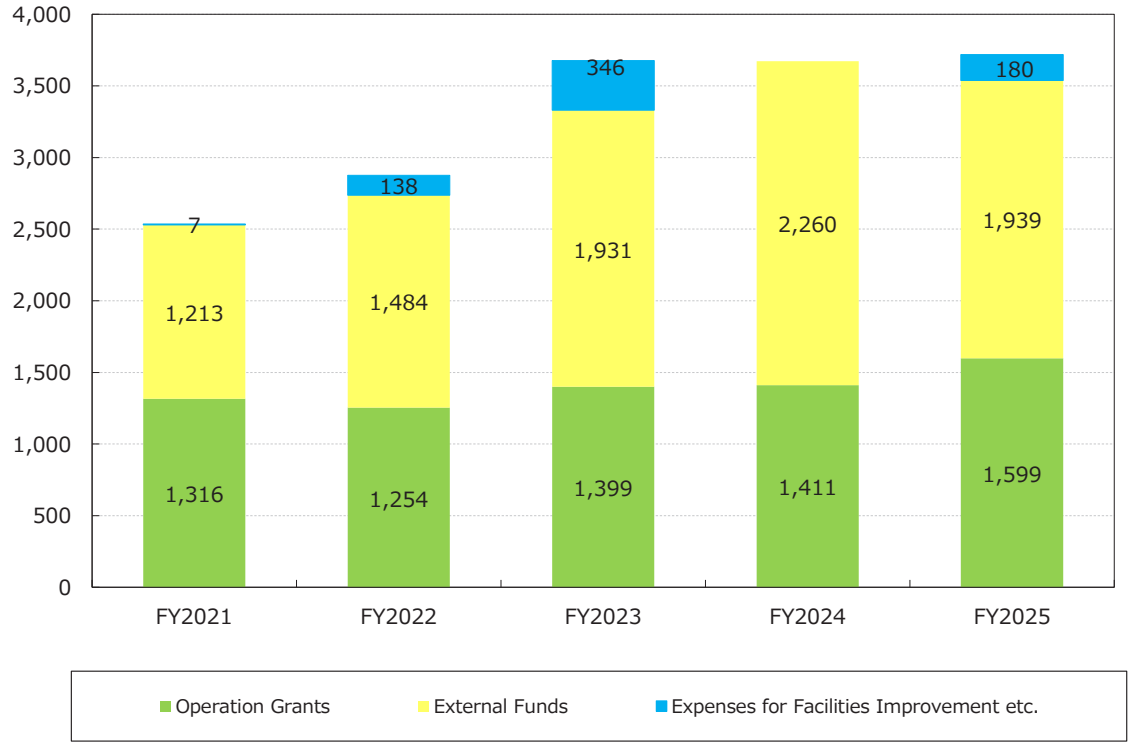
as of May 1, 2025

	School of Engineering	Graduate School of Information Science	Graduate School of Biomedical Engineering	RIEC	Total
Undergraduate Students	49 (2)				49 (2)
Master Course Students	92 (3)	47 (8)	5		144 (11)
Doctor Course Students	28 (8)	15 (6)	3		46 (14)
Institute Reserch Students				2 (1)	2 (1)
Total	169 (13)	62 (14)	8	2 (1)	241 (28)

4. Budget

Budget Shift

million yen



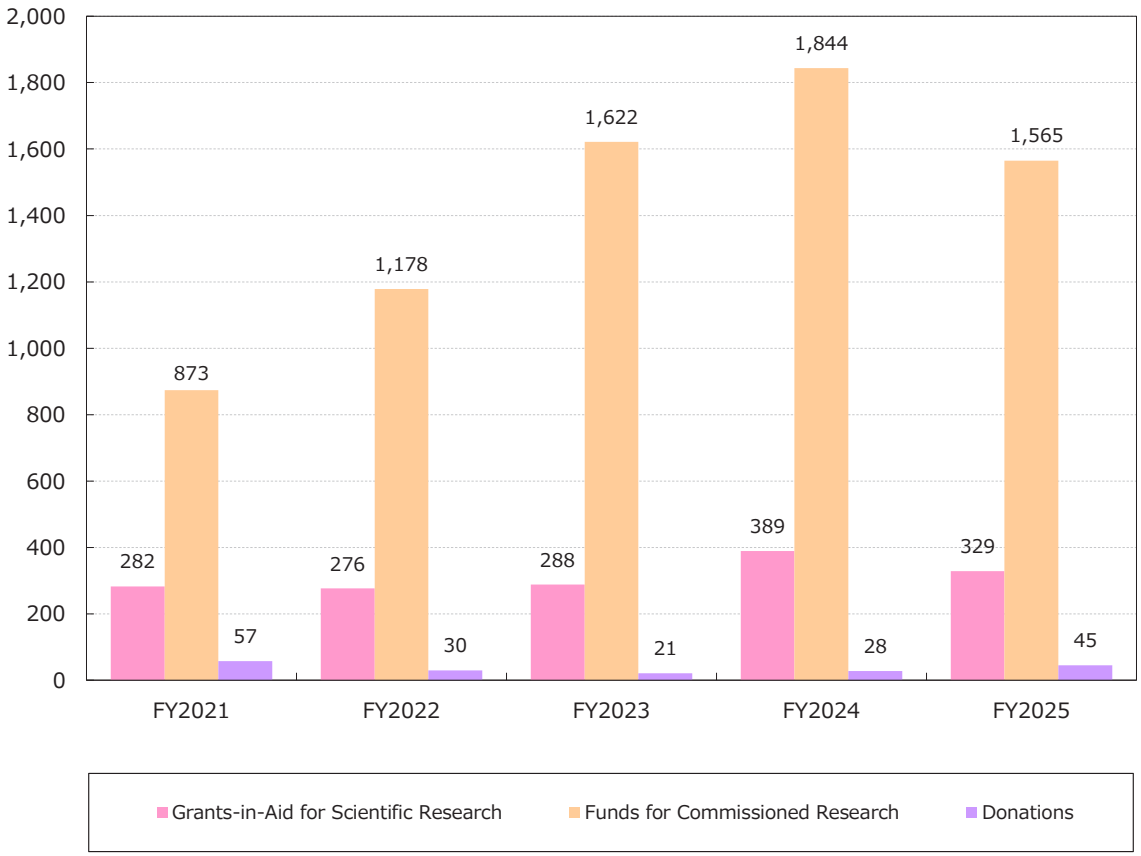
■ Budget Summary

thousand yen

Categories		FY2021	FY2022	FY2023	FY2024	FY2025
Operation Grants	Personnel Expenses	744,591	699,851	771,183	778,868	799,563
	Non-Personnel Expenses	571,737	553,851	628,159	632,286	799,554
Operation Grants Total		1,316,328	1,253,702	1,399,342	1,411,154	1,599,117
Grant for the University for International Research Excellence Total						103,528
External Funds	Grants-in-Aid for Scientific Research	282,400	276,146	287,842	388,615	328,636
	Funds for Commissioned Research	873,456	1,178,325	1,621,769	1,843,955	1,565,209
	Donations	57,422	29,604	21,000	27,611	45,184
	Indirect Expenses	234,487	315,346	455,413	518,716	426,522
External Funds Total		1,213,278	1,484,075	1,930,611	2,260,181	1,939,029
Expenses for Reconstruction		6,732	20,472	32,956	0	0
Expenses for Relocation		0	0	0	0	179,879
Expenses for Facilities Improvement		0	117,997	313,203	0	0
Expenses for Facilities Improvement etc. Total		6,732	138,469	346,159	0	179,879
Total		2,536,338	2,876,246	3,676,112	3,671,335	3,821,553

External Funds

million yen



■ External Funds

thousand yen

Categories	FY2021	FY2022	FY2023	FY2024	FY2025
Grants-in-Aid for Scientific Research	282,400	276,146	287,842	388,615	328,636
Funds for Commissioned Research	873,456	1,178,325	1,621,769	1,843,955	1,565,209
Donations	57,422	29,604	21,000	27,611	45,184
Total	1,213,278	1,484,075	1,930,611	2,260,181	1,939,029

Annual Report 2025

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