Annual Report 2024

Research Institute of Electrical Communication
Tohoku University

Annual report of Research Institute of Electrical Communication 2024

Contents

1. Introduction 1
2. Organization Chart 5
3. Research Activities 7

Research Divisions

- Computing System Platforms Division 7
- Information Communication Platforms Division 18
- Human and Bio Information Systems Division 28

Laboratories and Centers

- Laboratory for Nanoelectoronics and Spintoronics 40
- Laboratory for Brainware Systems 45
- Research Center for 21st Century Information Technology 48
- Interdisciplinary ICT Research Center for Cyber and Real Spaces 54
- Co-creation Research Center 56
- Management Office for Safety and Health 57
- Flexible Information System Center 59
- Fundamental Technology Center 61
- Ad-hoc research groups 62

Related Organizations and Programs, etc.

- Center for Science and Innovation in Spintronics (CSIS) 63
- Advanced Institute of So-Go-Chi (Convergence Knowledge) Informatics (So-Go-Chi) 64
- Center for Innovative Integrated Electronics Systems (CIES) 65
- Advanced Graduate Program for AI Electronics 68

4. Nation-wide Cooperative Research Projects 69
5. Symposium Organized by the Institute 81
6. International Activities 82
7. Periodicals Published by the Institute 84
8. Staff, Budget 85

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.

Since FY 2023, 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.

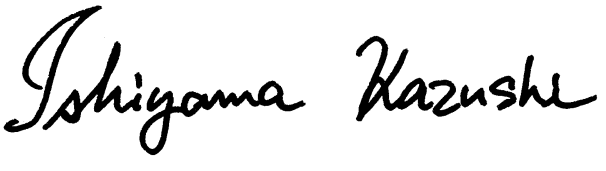
We will continue to address these social needs by fully leveraging our strengths as a university-affiliated research center. In doing so, we hope to forge the path to a new world of communication, and through these efforts continue to promote education going forward.

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.

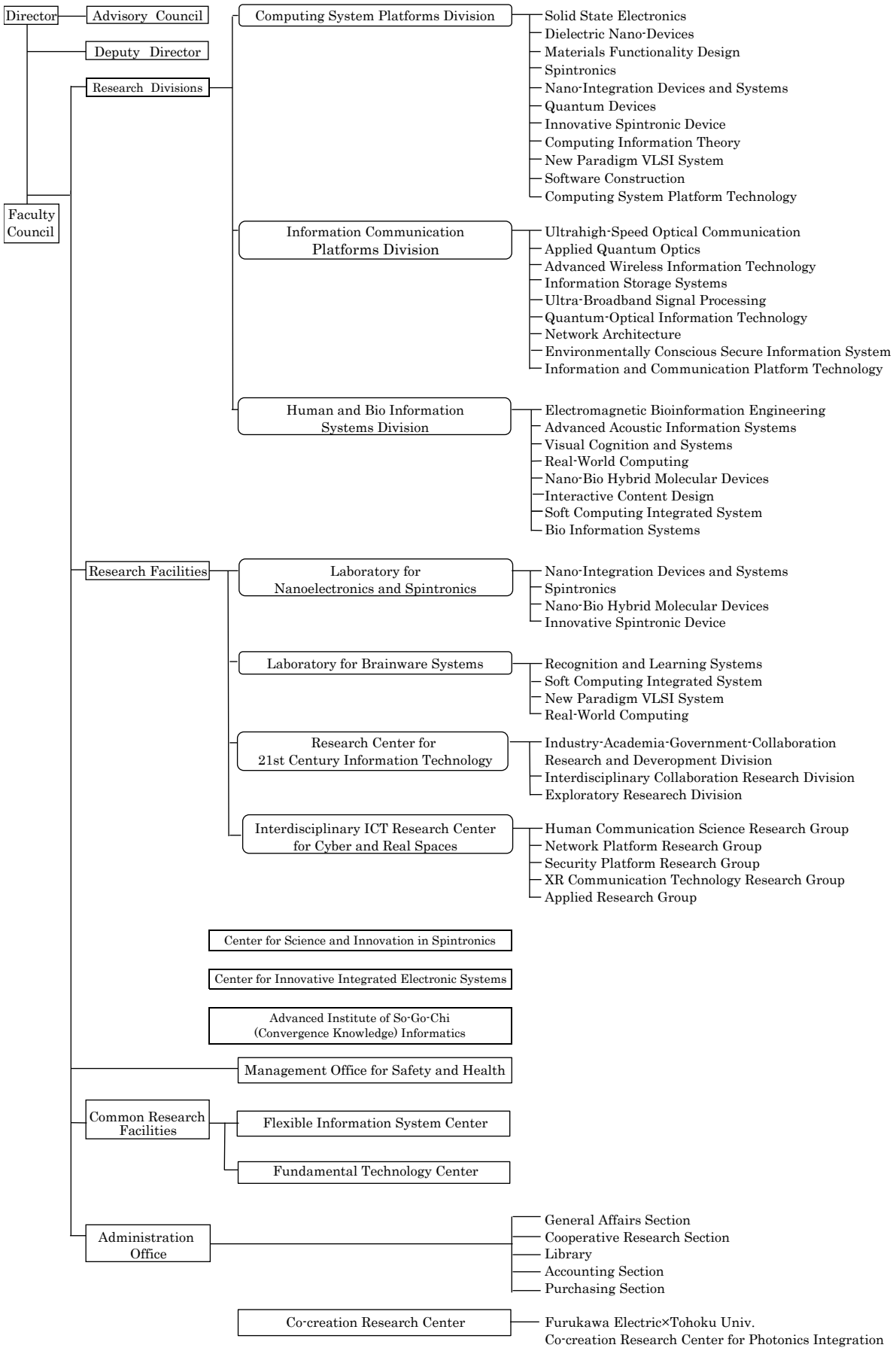
We welcome your frank opinions regarding our activities and look forward to your continued guidance and support in the future.

2025

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 11 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. Computing System Platform (Visitor Section)

The research target and the summary of activities of each sub-division in FY2024 are described in the following pages.

Solid State Electronics Laboratory

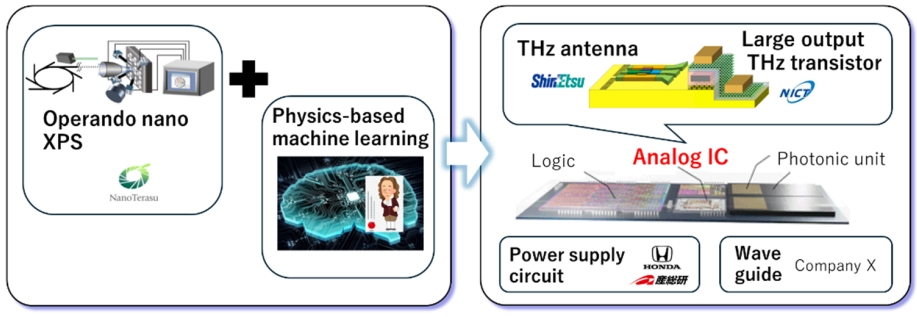
Development of Ultimate Transistors and an Advanced Research Platform for Devices and Circuits

Solid State Physics for Electroncis: Hirokazu Fukidome, Associate Professor

[Research Target and Activities]

We aim to realize the ultimate transistor with a gate length reduced 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 2024, we successfully fabricated a transistor with an atomically thin channel and an atomically short gate by orthogonally growing graphene and 2D semiconductors. This fabrication process has been published in a peer-reviewed journal. Furthermore, we advanced a white-box DI approach based on an extended free-energy model visualized in a cyberspace environment, and the achievement was published also in a peer-reviewed journal. 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 that spans the full spectrum from materials to devices to final products.



Beyond 5G R&G、CREST, JST-MIRAI、Shinetsu contract research、HONDA contract research

The summary of our work.

[Staff]

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

[Profile]

Prof. Hirokazu Fukidome received a Ph.D. in chemistry from Osaka University. After serving for Bell Labs and RIKEN, he became assistant professor at RIEC in 2008. He has been 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 (2011). M. Ishida Research Foundation Award (2015). RIEC Award (2016).

[Papers]

[1] Y. Tateno, F. Mitsuhashi, M. Okada, H. Fukidome, M. Adachi, Y. Yamamoto, M. Ueno, T. Nakabayashi, K. Nakata, “An Investigation to Determine the Interface Condition Between Graphene and SiC Substrate”, e-Journal of Surface Science and Nanotechnology, 22, 342-350 (2024).
[2] A. Ueda, H. Imamura and H. Fukidome, “High-frequency characteristics of ultra-short gate MoS_2 transistors”, APEX 18, 034005 (2025).
[3] 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: Method, 5, 2475735 (2025).

Contact to Associate Professor FUKIDOME Hirokazu : hirokazu.fukidome.e7@tohoku.ac.jp

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.

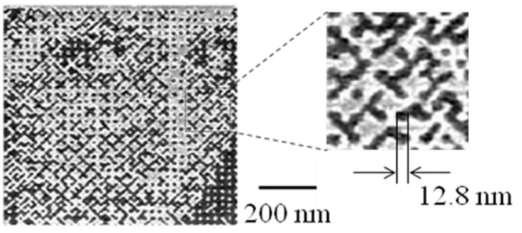


Fig.1 Digital bit data written on ferroelectric single crystal with the areal recording density of 4 Tbit/inch^2.

Major achievements of studies in 2024 are as follows: (1) We developed an analysis method based on spatial derivatives for hyperspectral image data obtained by the local C-V mapping method, and successfully visualized the boundaries between regions with different dynamic domain behaviors. Furthermore, we developed an integrated evaluation system combining the local C-V mapping method and piezoelectric response microscopy, and successfully evaluated ferroelectric polarization behavior from multiple perspectives. (2) We performed nanoscale evaluation of diamond and atomic-layer semiconductors through local DLTS and CV profiling using time-resolved SNDM. We also used a device simulation environment, developed in the previous year, to assess the impact of spatial fluctuations of interface charges on the electrical characteristics of power MOSFETs.

[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] A. Sumiyoshi, K. Yamasue, Y. Cho, and J. Nakamura, Sci. Rep. Vol. 15, Art. No. 7436 (2025)
[2] Y. Hiranaga, Y. Noguchi, T. Mimura, T. Shimizu, H. Funakubo, and Y. Cho, ACS Appl. Nano Mater. **7**, 8525 (2024).

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 2024 are as follows:

(1) Design of ferromagnetic electrode materials for magnetic tunnel junctions (MTJs)

We explored new ferromagnetic materials for MgO-based MTJs, which have perpendicular magnetic anisotropy (PMA), by using *ab initio* calculations. As a result, we found that metastable bcc Co-Mn and Co-Mn-Fe alloys have large PMA caused by tetragonal strain and thus those are promising candidates for electrode materials of MgO-based MTJs [1].

(2) Anharmonic proton dynamics in dense hydrogen

The anharmonic zero-point energy of protons is analyzed in dense hydrogen with the use of the self-consistent harmonic approximation. The inclusion of anharmonicity makes several isotropic structures dynamically stable and competitive above about 4 TPa. The transition pressure into an isotropic phase is predicted to be 3.7 TPa while it is 5 TPa in the harmonic approximation. Anharmonicity also plays an important role in the structure optimization, which significantly affects the phase diagram, especially, below 3 TPa. [3]

[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] D. Kumar, M. Ishibashi, T. Roy, M. Tsujikawa, M. Shirai, and S. Mizukami, “Metastable body-centered cubic CoMnFe alloy films with perpendicular magnetic anisotropy for spintronics memory,” Sci. Technol. Adv. Mater., Vol. 25, pp. 2421746/1-11, 2024
[2] Y. Saito, T. Roy, S. Ikeda, M. Shirai, H. Honjo, H. Inoue, and T. Endoh, “Strong antiferromagnetic interlayer exchange coupling induced by small additions of Re to an Ir interlayer in synthetic antiferromagnetic systems,” Sci. Rep., Vol. 15, pp. 8977/1-8, 2025
[3] K. Abe, “Structures of hydrogen at terapascal pressures,” Phys. Rev. B, Vol. 111, pp. 094103/1-8, 2025

Contact to Professor SHIRAI Masafumi : masafumi.shirai.b8@tohoku.ac.jp

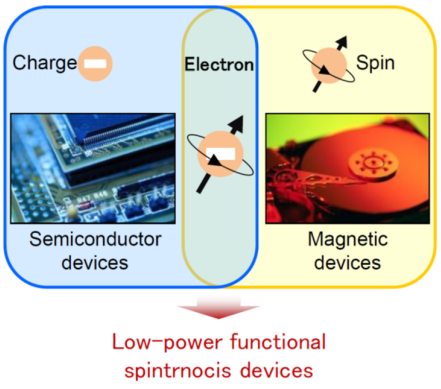
Spintronics

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, and JSPS Prize (2023).

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), and Funai Academic Award (2025).

[Papers]

[1] J. Han, T. Uchimura, Y. Araki, J.-Y. Yoon, Y. Takeuchi, Y. Yamane, S. Kanai, J. Ieda, H. Ohno and S. Fukami, "Room-temperature flexible manipulation of the quantum-metric structure in a topological chiral antiferromagnet," *Nature Physics* **20**, 1110–1117 (2024). doi:10.1038/s41567-024-02476-2

[2] M. Kawahara, Y. Abe, K. Takano, F.J. Heremans, J. Ishihara, S.E. Sullivan, C. Vorwerk, V. Somjit, C.P. Anderson, G. Wolfowicz, M. Kohda, S. Fukami, G. Galli, D.D. Awschalom, H. Ohno, and S. Kanai, "Polarization-dependent photoluminescence of Ce-implanted MgO and MgAl2O4," *Applied Physics Express* **17**, 072004(1)-(4) (2024). doi:10.35848/1882-0786/ad59f4

[3] N. S. Singh, C. Delacour, S. Niazi, K. Selcuk, D. Golenchenko, H. Kaneko, S. Kanai, H. Ohno, S. Fukami and K. Y. Camsari, "Beyond Ising: Mixed Continuous Optimization with Gaussian Probabilistic Bits using Stochastic MTJs," 70th Annual IEEE International Electron Devices Meeting (IEDM 2024), Digest of Technical Papers, doi: 10.1109/IEDM50854.2024.10873478

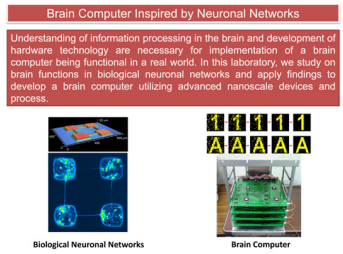
Nano-Integration Devices and Systems

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 evaluated the performance of a reservoir computing system using a spiking neural network (SNN) capable of operating with extremely low power consumption. Through applications to tasks such as speech recognition, we demonstrated that the system operates with approximately 1/100th the power consumption compared to conventional digital circuits, thereby highlighting its potential for edge computing applications. (2) We found that voltage shifts suggesting two types of charge injection and trapping occurred in MOS capacitors fabricated by thermally oxidizing an a-Si film on a 4H-SiC substrate. Furthermore, we successfully confirmed clear differences in the formation of accumulation and depletion layers in MOS capacitors fabricated in each region on a 3C-SiC/4H-SiC hybrid substrate. (3) We developed microfluidic devices that enable simultaneous control of connection directionality and modular structure in cultured neuronal networks and found that embedding directionality in intermodular connections diversifies spontaneous activity patterns.



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, Y. Cho, M. Abe, T. Tanno, M. Musya, M. Sakuraba, Y. Sato, S. Sato, "SNDM Study of the MOS Interface State Densities on the 3C-SiC/4H-SiC Stacked Structure," Solid State Phenomena, vol. 362, pp. 33-40, 2024.

[2] N. Monma, H. Yamamoto, N. Fujiwara, H. Murota, S. Moriya, A. Hirano-Iwata, S. Sato, “Directional intermodular coupling enriches functional complexity in biological neuronal networks,” Neural Networks, vol. 184, 106967, 2025.

Contact to Professor SATO Shigeo : shigeo.sato.e3@tohoku.ac.jp

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 2024 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 the methods using informatics approaches and new materials [1].

(2) Measurement of local electronic states in nanostructures

We measured local electronic and spin states in nanostructures using sensitive electronic measurement techniques. We revealed the local electronic states in nanostructures and in new materials.

(3) Development of quantum devices and systems

We studied semiconductor quantum devices and systems for quantum information processing. We investigated the analysis and control of quantum states, and developed techniques for scaling up the systems and creating devices based on new materials [2, 3].

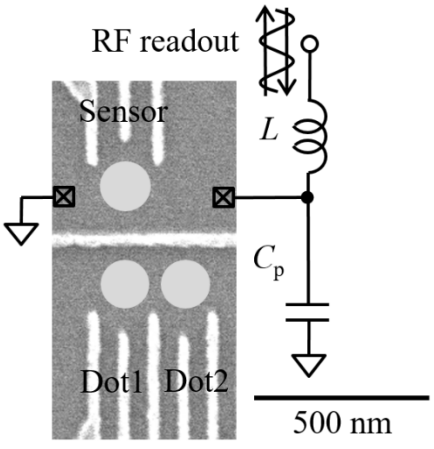


Figure: Scanning electron micrograph of a nanostructure device

[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] "Charge-state estimation in quantum dots using a Bayesian approach", M. Shinozaki, Y. Muto, T. Kitada, and T. Otsuka, Physical Review Applied 23, 034078 (2025).

[2] "Parity-independent Kondo effect of correlated electrons in electrostatically defined ZnO quantum dots", K. Noro, Y. Kozuka, K. Matsumura, T. Kumasaka, Y. Fujiwara, A. Tsukazaki, M. Kawasaki, and T. Otsuka, Nature Communications 15, 9556 (2024).

[3] "Visual explanations of machine learning model estimating charge states in quantum dots", Y. Muto, T. Nakaso, M. Shinozaki, T. Aizawa, T. Kitada, T. Nakajima, M. R. Delbecq, J. Yoneda, K. Takeda, A. Noiri, A. Ludwig, A. D. Wieck, S. Tarucha, A. Kanemura, M. Shiga, and T. Otsuka, APL Machine Learning 2, 026110 (2024).

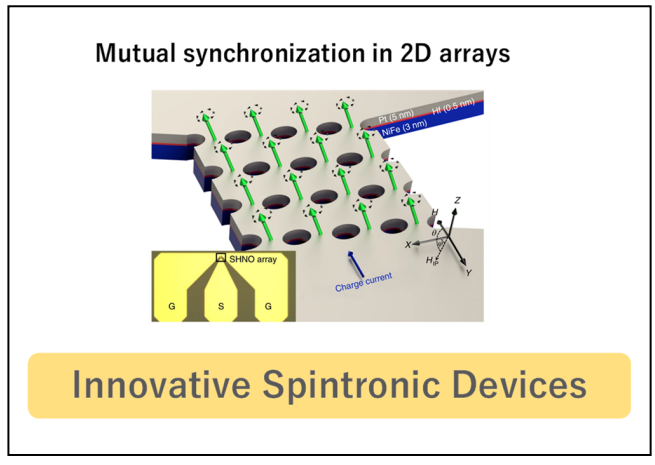
Innovative Spintronic Device

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

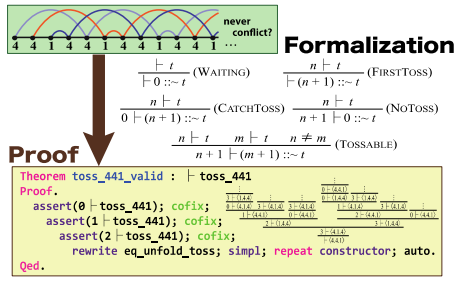
Contact to Professor Johan Åkerman : aakerman.bengt.johan.e3@tohoku.ac.jp

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]

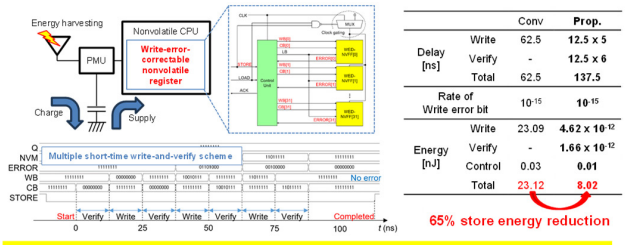
Keisuke Nakano received his Ph.D. from Kyoto University in 2006. He worked as a researcher atthe University of Tokyo from 2003 to 2008. He has been an assistant professor from 2008 to 2012 and an associate professor from 2012 to 2018 at the University of Electro-Communications. Since 2018, he has been 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] Paul Gallot, Sebastian Maneth, Keisuke Nakano, Charles Peyrat:Deciding Linear Height and Linear Size-To-Height Increase of Macro Tree Transducers. ICALP 2024: 138:1-138:20
[2] Keisuke Nakano, Munehiro Iwami:Disproving Termination of Non-erasing Sole Combinatory Calculus with Tree Automata. CIAA 2024: 261-275
[3] Keishi Hashiba, Keisuke Nakano, Kazuyuki Asada, Kentaro Kikuchi:
Characterizations of Partial Well-Behaved Lenses. PEPM 2025: 43-53
[4] Kazuki Watanabe, Clovis Eberhart, Kazuyuki Asada, Ichiro Hasuo:Compositional Solution of Mean Payoff Games by String Diagrams Principles of Verification: Cycling the Probabilistic Landscape Essays Dedicated to Joost-Pieter Katoen on the Occasion of His 60th Birthday, Part III LNCS 15262, pp. 423-445

New Paradigm VLSI System Research Group

Realization of a New-Paradigm VLSI-Computing World

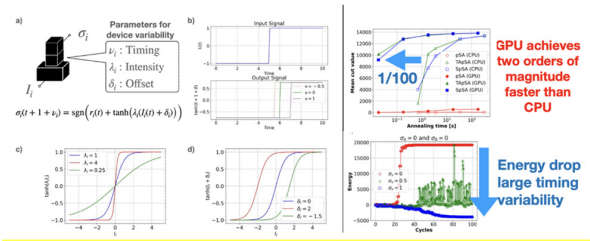


		Conv	Prop.
Delay [ns]	Write	62.5	12.5 x 5
	Verify	-	12.5 x 6
	Total	62.5	137.5
Rate of Write error bit		10^{-15}	10^{-15}
Energy [nJ]	Write	23.09	4.62×10^{-12}
	Verify	-	1.66×10^{-12}
	Control	0.03	0.01
	Total	23.12	8.02

65% store energy reduction

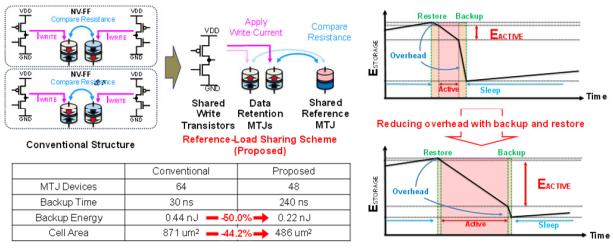
Nonvolatile Register with a Switching-Probability-Aware Store-and-Verify Scheme

M. Natsui, et. al, IEEE ACCESS, 2025.



GPU-accelerated simulated annealing with p-bit device variability modeling

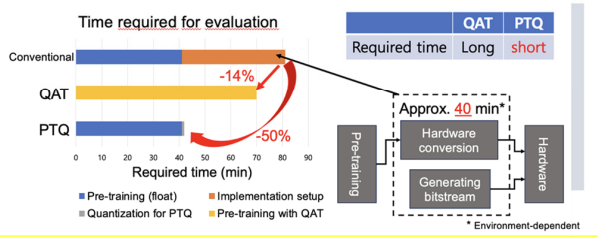
N. Onizawa and T. Hanyu, Scientific Reports, Feb. 2025.



	Conventional	Proposed
MTJ Devices	64	48
Backup Time	30 ns	240 ns
Backup Energy	0.44 nJ -50.0%	0.22 nJ
Cell Area	87.1 um² -44.2%	486 um²

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

T. Yoshida, et. al., IEEE MWSCAS, 2024.



Required times are reduced through skipping subsequent phases

R. Kanda, et al., IEEE MWSCAS 2024

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]

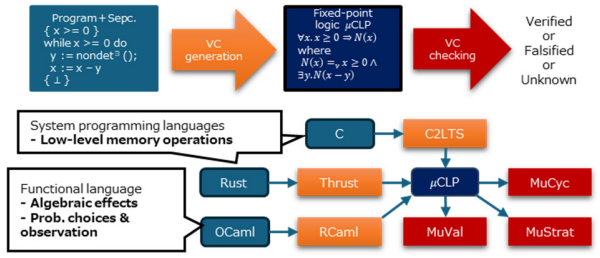
[1] M. Natsui and T. Hanyu, "Design of an Intermittent-Computing-Oriented Nonvolatile Register with a Switching-Probability-Aware Store-and-Verify Scheme," IEEE ACCESS, vol. 13, pp. 38104-38114, Feb. 2025. DOI: 10.1109/ACCESS.2025.3546590
[2] N. Onizawa, R. Sasaki, D. Shin, W. J. Gross, and T. Hanyu, "Stochastic Simulated Quantum Annealing for Fast Solution of Combinatorial Optimization Problems" IEEE Access, vol.12, pp.102050-102060, 2024. DOI: 10.1109/ACCESS.2024.3431540
[3] R. Kanda, N. Onizawa, M. Leonardon, V. Gripon, and T. Hanyu, "Design Environment of Quantization-Aware Edge AI Hardware for Few-Shot Learning," MWSCAS 2024, pp.928-931 (4 pages), Aug. 2024.
[4] K. Asano, M. Natsui, and T. Hanyu, "Error-Tolerance-Aware Write-Energy Reduction of MTJ-Based Quantized Neural Network Hardware," IEICE, Trans. on Electronics, vol. E107-D, no.8, pp.958-965 (8pages), April 2024. DOI: 10.1587/transinf.2023LOP0007

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.

This year, we proposed a refinement type system for verifying temporal specifications of object-oriented and concurrent programs, and introduced a method that reduces the type checking problem to constraint solving over regular expressions [3]. We also developed a novel approach for solving the satisfiability problem of higher-order quantified Boolean formulas by reducing it to higher-order model checking, and implemented the world's first solver for this problem [1]. Furthermore, we proposed a new theoretical framework for program verification based on the Lagrangian concept from mathematical optimization, which elucidates the inherent primal-dual structure of verification methods and enables the derivation of new approaches such as our fixpoint logic solver MuStrat [2].

[Staff]

Professor : Hiroshi Unno, 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] Hiroshi Unno, Takeshi Tsukada, and Jie-Hong Roland Jiang. Solving Higher-Order Quantified Boolean Satisfiability via Higher-Order Model Checking, Proc. AAAI Conference on Artificial Intelligence, 39(11), pp.11372-11380, February, 2025.

[2] Takeshi Tsukada, Hiroshi Unno, Oded Padon, and Sharon Shoham. A Primal-Dual Perspective on Program Verification Algorithms, Proc. ACM on Programming Languages, Volume 9, Issue POPL, ACM, Article No. 68, pp.2025-2056, January, 2025.

[3] Taro Sekiyama and Hiroshi Unno. Algebraic Temporal Effects: Temporal Verification of Recursively Typed Higher-Order Programs, Proc. ACM on Programming Languages, Volume 9, Issue POPL, ACM, Article No. 78, pp.2306-2336, January, 2025.

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, by increasing the symbol rate in our coherently-linked optical and wireless transmission, we successfully achieved 108 Gbit/s-64 QAM signal transmission over 10 km of SMF and 10 m of wireless transmission at 30 GHz IF. We also proposed a Nyquist pulse TDM transmission using an all-digital scheme, and successfully demonstrated 40 Gbaud, 16 QAM (320 Gbit/s) Nyquist pulse transmission over 4,000 km.

(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.

For a study on an ultra-high-speed semiconductor laser, it was confirmed numerically that the intrinsic modulation bandwidth of a hybrid modulation semiconductor laser we proposed can be broadened to more than 500 GHz and high-speed dynamic-single-mode operation up to 500 Gbit/s can be expected. We also developed a narrow-linewidth continuous-wave laser phase-locked to a high-Q Fabry–Pérot cavity as a light source for precise compensation of phase fluctuations in optical fibers. Moreover, we demonstrated that the polarization bistability of a vertical-cavity surface-emitting laser can be controlled by electron spin precession.

(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 invented novel distributed scalable DBF array antenna system for on-board units of LEO constellation satellites.

(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 and web services. In addition, research into magnetic devices for neuromorphic applications is also ongoing.

We have been investigating novel, three-dimensional, energy-assisted recording technologies that enable selective recording on media with multiple, discrete recording layers. This year, our research concentrated on heat-assisted magnetic recording (HAMR), with the aim of doubling the storage capacity. We have also been studying arrays of stochastic magnetic tunnel junctions for use as logic gates.

(5) Ultra-Broadband Signal Processing

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

First, topological semi-metallic Bi_2Se_3 thin films were grown by liquid-phase epitaxy and fabricated into devices as tunnel diode rectennas. We succeeded for the first time in realizing a high-speed, high-sensitivity terahertz detection with non-energy-consumption and non-biased conditions, reflecting their unique properties of asymmetric relativistic Dirac fermions of electrons and holes. Second, regarding the optical-to-wireless carrier frequency down-conversion device which is one of key technologies in future optical-wireless convergence networks, we achieved the conversion gain of -72 dB for the 300-GHz-band carrier frequency down-conversion using a photonic double-mixer based on an InGaAs-channel high-electron-mobility and succeeded in the first demonstration of 1-THz-band carrier frequency down-conversion using a graphene-channel field-effect transistor.

(6) Quantum-Optical Information Technology

Our goal is to develop quantum information devices utilizing the quantum interaction between photons and electrons in solids.

In 2024, we have achieved (1) development of plasmon-enhanced single photon source coupled to an optical nanofiber, (2) development of ultra-low-loss, polarization-maintaining photon switch, (3) development of ultrapure heralded single photon source via controlled quasi-phase-matched parametric down-conversion, and (4) evaluation of error-disturbance uncertainty relation using small-scale superconducting quantum computer.

(7) Network Architecture

We have promoted research on information network systems and their applications that support diverse human activities. (1) We conducted experimental evaluations of a novel in-network congestion control architecture that fundamentally overturns conventional concepts, and confirmed its effectiveness in real-world environments. (2) We developed a new algorithm that significantly mitigates throughput unfairness caused by communication distance on the Internet. (3) We promoted the application of traffic compression technology, originally designed for remote management of network devices, to log data collection. (4) We established a mathematical approach to enhance fault tolerance by optimizing both the implementation and redundancy configurations of network applications composed of numerous functions.

(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 an efficient and valid countermeasure, known as jump address masking, against fault injection attacks. We also succeeded in a new memory encryption scheme that can be adapted to peta-scale memory size.

Research Laboratory of Ultrahigh-Speed Optical Communication

Toward Innovative Optical Transmission from Backbone to Access Networks

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, by increasing the symbol rate, we successfully achieved 108 Gbit/s-64 QAM signal transmission over 10 km of SMF and 10 m of wireless transmission at 30 GHz IF.

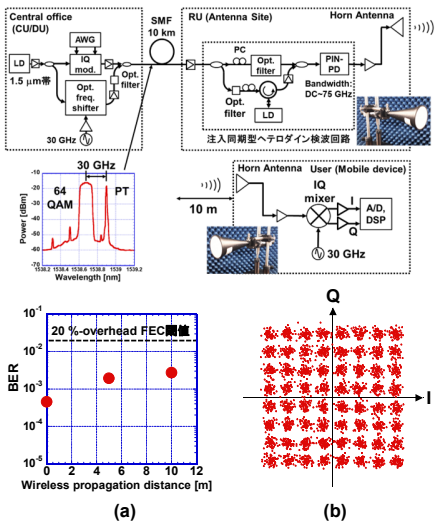


Fig. 1. 108 Gbit/s-64 QAM fully coherent transmission over a 10 km-SMF and 10 m wirelessly in 30 GHz-IF

[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] S. Beppu, A. Ishikawa, T. Serikawa, M. Yoshida, T. Hirooka, and M. Nakazawa, "Coherent Nyquist optical pulse transmission at nearly 1-Tb/s/λ over 1,600 km with a capacity of 21.5 Tb/s using PS-32 QAM signals," Opt. Express vol. 32, no. 9, pp. 16533-16547, April (2024).
[2] K. Kasai, K. Shirahata, M. Yoshida, T. Hirooka, M. Nakazawa, U. Azuma, and T. Kobayashi, "Fully Coherent Mobile Fronthaul Transmission with a Very Large Loss Budget by Using Injection-Locked Heterodyne Detection," ECOC 2024, W2A.146, September (2024).
[3] S. Kumar, M. M. T. Maghrabi, M. H. Bakr, T. Hirooka, and M. Nakazawa, "Coherent all Optical Reservoir Computing for Equalization of Impairments in Coherent Fiber Optic Communication Systems," IEEE Photon. J. vol. 16, no. 5, 7202210, October (2024).

Contact to Professor HIROOKA Toshihiko : toshihiko.hirooka.a8@tohoku.ac.jp

Applied Quantum Optics

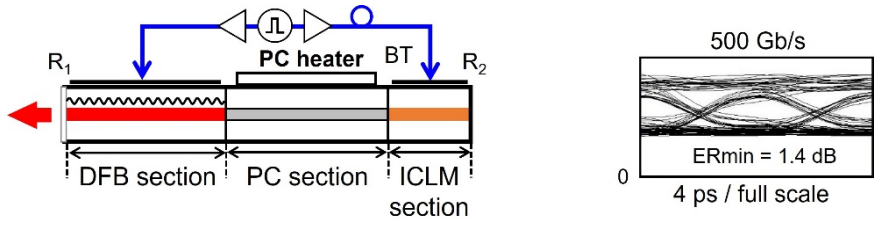
Research on Innovative Highly Functional Photonic Semiconductor Devices

Highly Functional Photonics — **Hiroshi Yasaka, Professor**
High accuracy optical measurement — **Masato Yoshida, Associate Professor**
Emerging semiconductor light source — **Nobuhide Yokota, Associate Professor**

[Research Target and Activities]

Novel functional photonic devices including high function laser diode (LD) sources are being investigated to explore new-generation photonic network systems.

The study on ultra-high-speed semiconductor lasers is being continued. It was confirmed numerically that a hybrid modulation semiconductor laser integrated with a passive waveguide as a phase controller has wide intrinsic modulation bandwidth more than 500 GHz thanks to the optical pre-emphasis of the modulation response by the photon-photon resonance effect. And clear eye opening under high speed digital modulation signal up to 500 Gbit/s was confirmed.



Schematic structure of a hybrid modulation laser integrated with a passive waveguide (left) and its eye diagram under 500 Gbit/s operation (right).

[Staff]

Professor : Hiroshi Yasaka, Dr.
Associate Professor : Masato Yoshida, Dr.
Associate Professor : Nobuhide Yokota, Dr.

[Profile]

Hiroshi Yasaka received Ph.D. degree in electronic engineering from Hokkaido University in 1993. In 1985 he joined Nippon Telegraph and Telephone (NTT) Corporation. From 2008 he has been a professor of Research Institute of Electrical Communication, Tohoku University.

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.

Nobuhide Yokota received Ph.D. degree in engineering from Nara Institute of Science and Technology in 2014. In 2014, he joined the Research Institute of Electrical Communication, Tohoku University. He is currently an Associate Professor of the Institute.

[Papers]

[1] H. Yasaka, N. Yokota, T. Shindo, and W. Kobayashi, "Numerical Analysis for High-speed Hybrid-modulation Semiconductor Laser Integrated with Passive Waveguide," IEEE Journal of Quantum Electronics, vol. 60, No. 4, pp. 2000408, 2024.
[2] H. Yasaka, N. Yokota, T. Shindo, and W. Kobayashi, "Intrinsic Modulation Characteristics of Hybrid Modulation Laser Diode with Phase Control Waveguide," IEEE Journal of Quantum Electronics, vol. 61, No. 1, pp. 2200108, 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.

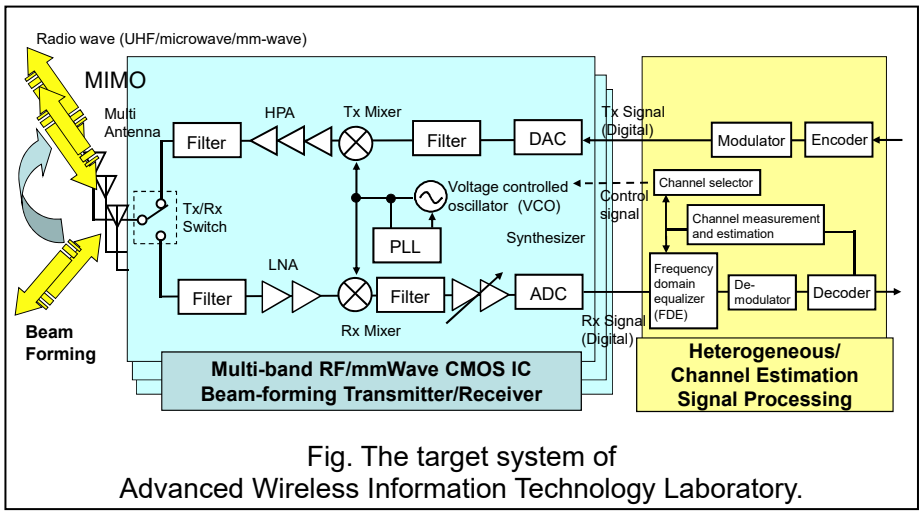


Fig. The target system of
Advanced Wireless Information Technology Laboratory.

This year, we have successfully developed a millimeter-wave Vivaldi array antenna module which can be merged with DBF direct digital RF transmitter module. We have also revealed measured RF characteristics of H-terminated diamond FET under high-temperature operation up to 250°C and have investigated its characteristics using simple RF modeling.

[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 and Prize for Science and Technology, the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology in 2009.He is a fellow of IEICE

[Papers]

[1] K. Furuuchi, J. Zhang, T. Furuichi and N. Suematsu, "40GHz-Band Low-Backlobe Low-Mutual-Coupling Vivaldi Antenna Array Using Double-Slits for Antenna Integrated Module," 2024 IEEE Asia-Pacific Microwave Conference (APMC), Bali, Indonesia, 2024
[2] T. Furuichi et al., "High-Temperature Operation and RF Characteristics Measurement of H-Terminated Diamond FET," 2024 IEEE Asia-Pacific Microwave Conference (APMC), Bali, Indonesia, 2024.

Contact to Professor SUEMATSU Noriharu : noriharu.suematsu.a3@tohoku.ac.jp

Information Storage System Laboratory

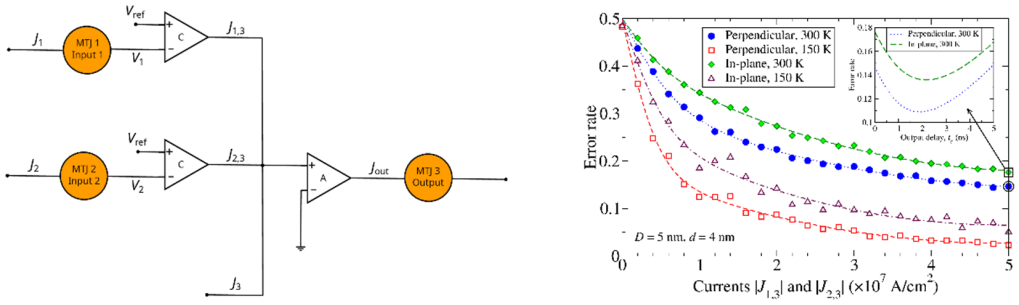
High-Density, Low-Cost Information Storage Devices

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]-[3]. In addition, we are studying the potential of magnetic devices such as magnetic tunnel junctions (MTJs) for use in neuromorphic computing applications [4]. The figure shows an example of an AND logic gate formed from three MTJs. The error rate can be minimised by adjusting the currents and device properties.



AND logic gate formed from three stochastic MTJs

[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] P. Tozman, S. Isogami, I. Suzuki, A. Bolyachkin, H. Sepehri-Amin, S. J. Greaves, H. Suto, Y. Sasaki, T. Y. Chang, Y. Kubota, P. Steiner, P.-W. Huang, K. Hono and Y. Takahashi, "Dual-layer FePt-C granular media for multi-level heat-assisted magnetic recording", Acta Materialia 271, 119869, (2024).

[2] S. J. Greaves, H. Suto, Y, Nakamura and Y. Kanai, "Effect of Curie temperature distributions on the user areal density of heat-assisted magnetic recording", IEEE Trans. Magn. 60(9), 3200605-1-5, (2024).

[3] S. J. Greaves and Y. Kanai, "Optimisation of microwave-assisted magnetic recording media for spin-torque oscillators with dual field generating layers", IEEE Trans. Magn. 61(4) 3200405-1-5, (2025).

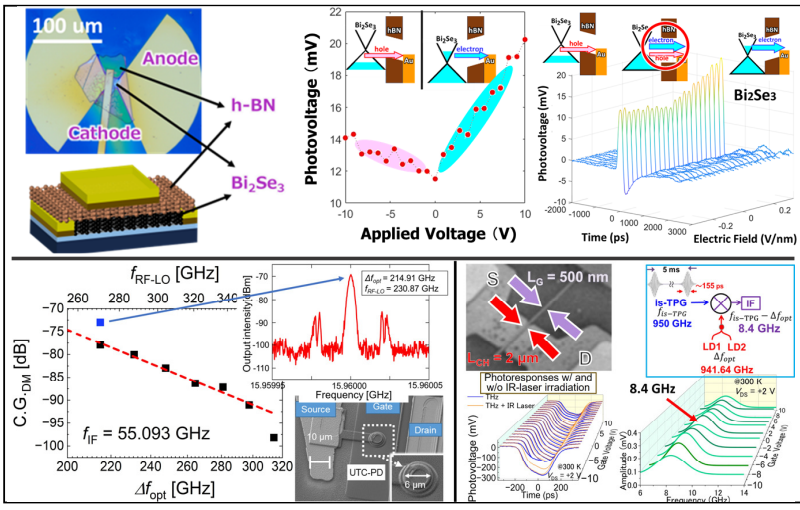
[4] S. Endo and S. J. Greaves, "Simulation of error rate of AND logic gates made with stochastic MTJs", AIP Advances 15, 035110-1-6, (2025).

Ultra-broadband Signal Processing

Novel Millimeter-wave and Terahertz Integrated Electron Devices and Systems

Ultra-Broadband Devices and Systems: Taiichi OTSUJI, Professor
Ultra-Broadband Device Physics: Akira SATOU, Associate Professor
Ultra-Broadband Quantum Electronics: Tsung-Tse LIN, Associate Professor

[Research Target and Activities]



Top: Dirac semi-metallic Bi_2Se_3 rectenna diode (left), asymmetric photovoltage response reflecting asymmetric Dirac dispersion (middle), and fast THz-wave detection temporal response waveform and demonstration of unplugged and non-biased detection (right).

Bottom: Demonstration of 300-GHz optical-to-wireless carrier frequency down-conversion by an InGaAs-based photonic double mixer (left) and demonstration of 1-THz down-conversion by a graphene-channel FET (right).

We are developing novel, integrated electron devices and circuit systems operating in the terahertz (THz) region. First, we have fabricated topological semimetallic Bi_2Se_3 films, in which electrons and holes behave as asymmetric relativistic Dirac particles, by liquid phase growth and fabricated them as tunnel rectenna diodes. We have successfully demonstrated asymmetric photoresponse properties reflecting asymmetric Dirac dispersion of Bi_2Se_3 fermions, and fast non-energy-consumption, non-biased THz wave detection thanks to its asymmetric dispersive nature, which is difficult to achieve with graphene materials. Second, regarding the photonic double-mixers for the carrier frequency down-conversion from optical to wireless data signals, which is one of key technologies in future photonics-electronics convergence networks, we achieved the conversion gain of -72 dB for the 300-GHz-band carrier frequency down-conversion using a photonic double-mixer based on an InGaAs-channel high-electron-mobility and succeeded in the first demonstration of 1-THz-band carrier frequency down-conversion using a graphene-channel field-effect transistor.

[Staff]

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

[Profile]

Taiichi OTSUJI: received the Dr. Eng. deg. from Tokyo Tech., Japan, in 1994. After working for NTT Labs., Japan, since 1984, he joined Kyutech in 1999, as an Assoc. Prof., being a prof. from 2002. Since 2005, he has been a Prof. at RIEC, Tohoku Univ., Japan. Recipient of the 2019 Prizes for Science and Technology, the Commendation for Science and Technology, MEXT, Japan. A Distinguished Lecturer, Electron Device Society, IEEE. A member of IEEE (Fellow), OSA (Fellow), JSAP (Fellow), IEICE (Senior), MRS, and SPIE.

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] C. Tang, K. Tamura, Ai Hamada, H. Kudo, S. Uchigasaki, Y. Takida, H. Minamide, T.-T. Lin, A. Satou, and T. Otsuji, "Bi_2Se_3/h-BN Heterostructure Rectenna for Fast and Sensitive THz Detection," DRC 2024, Univ. Maryland, MD, USA, June 24-26, 2024. DOI: 10.1109DRC61706

[2] T.-T. Lin, S. Horiuchi, M. Watanabe, S. Uchigasaki, K. Tamura, T. Suemitsu, T. Otsuji, and A. Satou, "300-GHz-Band Operation of UTC-PD-Integrated HEMT Photonic Double-Mixer," IRMMW-THz 2024, Perth, Australia, Sept. 1-6, 2024. DOI: 10.1109/IRMMW-THz60956.2024.10697824

[3] V. Ryzhii, M. Ryzhii, C. Tang, T. Otsuji, and M. Shur, "Resonant plasmonic terahertz photomixing using interdigital graphene micro-nanoribbon arrays," Appl. Phys. Lett., vol. 124, pp. 163504-1-6, April 2024. DOI: 10.1063/5.0204113

Quantum-Optical Information Technology

Development of optoelectronic devices for quantum information and communication technology

Quantum-Optical Information Systems: Soyoung Baek, Assistant Professor
Quantum-Optical Information Devices: Fumihiro Kaneda, Concurrent Professor (G. School of Science)

[Research Target and Activities]

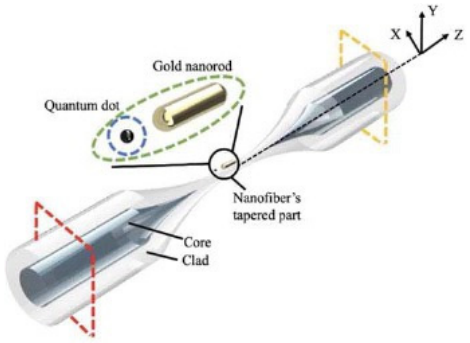


Fig 1

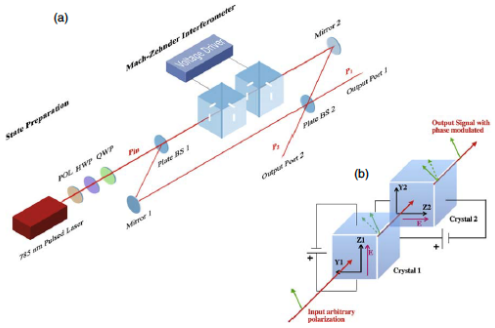


Fig 2

Fig.1. Plasmon-enhanced single photon source on an optical nanofiber.
Fig.2. Ultra-low-loss polarization-maintaining photon switch.

Our goal is to develop quantum information devices and systems utilizing quantum interaction between photons and electrons in solids. In 2024, we have achieved (1) development of plasmon-enhanced single photon source coupled to an optical nanofiber, (2) development of ultra-low-loss, polarization-maintaining photon switch, (3) evaluation of error-disturbance uncertainty relation using small-scale superconducting quantum computer, and (4) development of ultrapure heralded single photon source via controlled quasi-phase-matched parametric down-conversion.

[Staff]

Assistant Professor: Soyoung Baek, Dr.
Concurrent Professor : Fumihiro Kaneda, Dr. (Graduate School of Science, Tohoku University)

[Profile]

Soyoung Baek received B.S. and Ph.D. degrees in Physics from Pohang University of Science and Technology. She was a Postdoctoral Research Fellow in Department of Electrical and Computer Engineering, Duke University, and in Department of Physics, University of Illinois.
Fumihiro Kaneda received B.S. degree in Physics, M.S. and D.S. degrees in Engineering from Tohoku University. He was a Postdoctoral Research Fellow in University of Illinois, and an Assistant Professor in Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, and an Associate professor in Research Institute of Electric Communication, Tohoku University.

[Papers]

[1] P. Wang, S. Baek, M. Yabuno, S. Miki, H. Terai, and F. Kaneda, "Low-loss polarization-maintaining router for single and entangled photons at a telecom wavelength", arXiv:2502.12554 (2025) doi:10.48550/arXiv.2502.12554
[2] W.-H. Cai, S. Baek, R.-B. Jin , and F. Kaneda, "Optimized Spectral Purity of Heralded Single Photons at the Telecom O-Band", arXiv:2502.12554 (2025) doi:10.48550/arXiv.2501.14214
[3] P. Wang, S. Baek, K. Edamatsu, and F. Kaneda, "Low-loss polarization-maintaining optical router for photonic quantum information processing", Jpn. J. Appl. Phys. **63**, 040901/1-5 (2024) doi:10.35848/1347-4065/ad3533
[4] Y. Xuan, R. Sun, S. Baek. M. Sadgrove, and K. Edamatsu, "Numerical investigation of plasmon-enhanced emission from a nanofiber coupled single photon emitter", Appl. Phys. Exp. **17**, 012003/1-6 (2024) doi:10.35848/1882-0786/ad1318

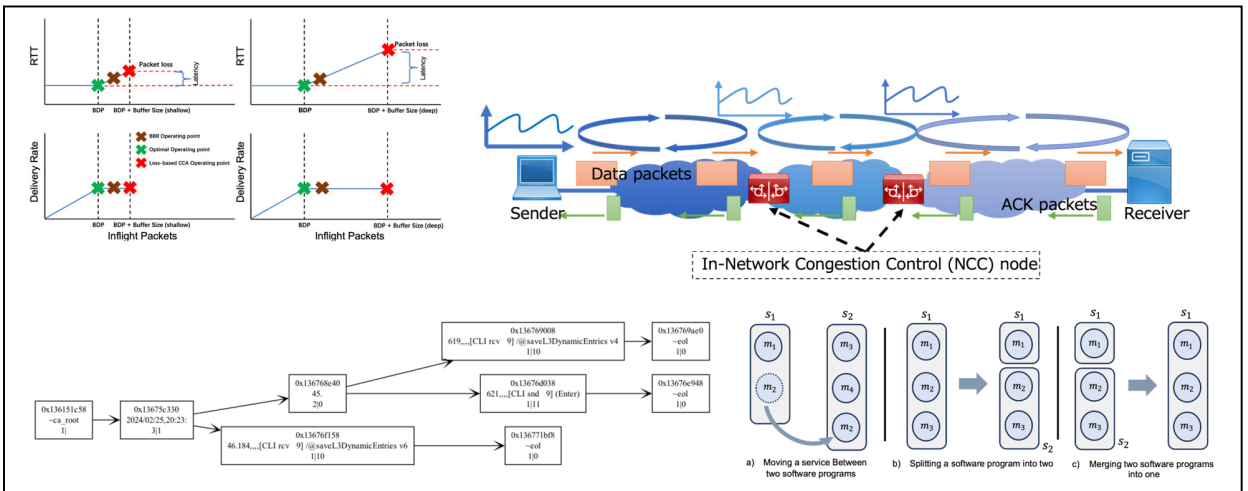
Network Architecture Lab.

Information Network Architecture for IoT/AI Era

Information Network Architecture: Go Hasegawa, Professor

[Research Target and Activities]

In this year, the following studies had been done. (a) Research on Internet congestion control including in-Network Congestion Control architecture and Machine learning-based estimation of network environment and its application to congestion control, (b) Research on virtualized network systems and applications, including mobile core network architecture for 5G and beyond, (c) Traffic compression technologies for remote network equipment operations, and (d) Optimization scheme for software implementation and redundancy configure considering failures.



Researches on Information Network Architecture for IoT/AI Era

[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, "Overcoming Fairness and Latency Challenges in BBR with an Adaptive Delay Detection," IEEE Access, Feb 2025.
[2] Zewei Han and Go Hasegawa, "BBR-R: Improving BBR's RTT Fairness by Dynamically Adjusting Delay Detection Intervals," in Proceedings of AINA 2024, April 2024.
[3] Zeyou Xia and Go Hasegawa, "Machine Learning-Based Estimation of the Number of Competing Flows at a Bottleneck Link," in Proceedings of IEEE/IFIP NOMS 2024 Workshop on Analytics for Network and Service Management, May 2024.

Contact to Professor HASEGAWA Go : go.hasegawa.a6@tohoku.ac.jp

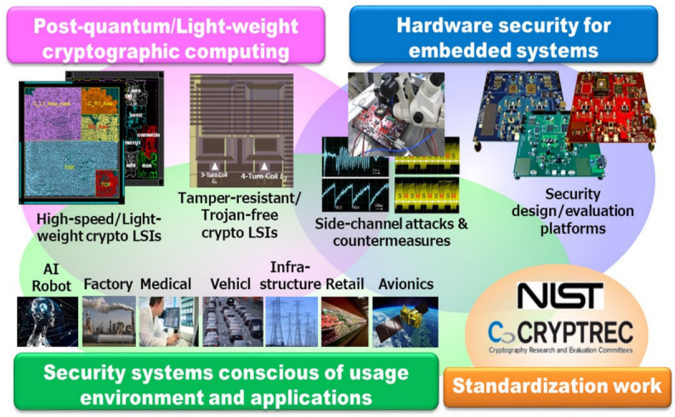
Environmentally Conscious Secure Information System Laboratory

Advanced information security technology

Environmentally Conscious Secure Information System, Naofumi Homma, 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 discovered and reported a critical security risk of computer architecture including memory isolation mechanism against fault injection attacks. We also developed an efficient and valid countermeasure, named jump address masking, against the fault injection attacks, which was applicable to RISC-V processors. In addition, we have developed a method to detect aging in microcontrollers by focusing on changes in voltage and electromagnetic (EM) emission during cryptographic operations, called side-channel information. Furthermore, we have developed a new memory encryption scheme that can be adaptable to peta-scale memory size. The developed scheme can reduce encryption-related delays by up to 63% and memory performance degradation by 44%.



[Staff]

Professor: Naofumi Homma, 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] Shoei Nashimoto, et. al., "Comparative Analysis and Implementation of Jump Address Masking for Preventing TEE Bypassing Fault Attacks," 2024 International Conference on Availability, Reliability, and Security (ARES 2024), No. 26, pp. 1-12, July 2024

[2] Yuki Kaneko, et. al., "Experimental Evaluation for Detecting Aging Effect on Microcontrollers based on Side-Channel Analysis," 14th International Workshop on the Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp. 243-247, Oct. 2024.

[3] Rei Ueno, et. al., "Crystalor: Recoverable Memory Encryption Mechanism with Optimized Metadata Structure," The 31th ACM Conference on Computer and Communications Security (CCS 2024), pp. 228-242, DOI:10.1145/3658644.3670273, October 2024.

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 Cognition and Systems, (4) Real-world computing, (5) Nano-Bio Hybrid Molecular Devices, (6) Interactive Content Design, (7) Soft Computing Integrated System.

The goals and achievements in the fiscal year 2024 of each laboratory are described in detail below.

(1) Electromagnetic Bioinformation Engineering

(Aims) This laboratory aims at obtaining the high accuracy sensor system for the signals from the human body or electric devices and at obtaining the system for approaching action to the human body by using the nano-scale controlled magnetic materials and by the development of the devices under the functions of the magnetics.

(Achievements) The main achievements in 2024 are as follows: (1) We developed and demonstrated an artificial heart utilizing magnetic technology. Conventional artificial hearts require tubes to penetrate the body surface, but this can be avoided by using magnetic technology. We created a demonstration device that operates in an environment simulating the human body, showing the usefulness of magnetic applications in biomedical devices. (2) Towards constructing a system that captures electromagnetic field information using magnetics and optics, we fabricated a magneto-optical structure that is highly sensitive to electromagnetic fields. The structure demonstrated large magneto-optical effects even in thin films, indicating the possibility of achieving both high spatial resolution and high sensitivity.

(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) We have focused on how people with listening difficulties recognize spatially distributed auditory information. In 2024, we investigated the effects of distractor sounds presented to the contralateral ear on speech intelligibility in patients with listening difficulties

without apparent peripheral pathology and in control participants. We also investigated whether hand movement affects auditory information processes as well as visual information processes. In addition, we developed advanced acoustic systems, such as 3D virtual auditory displays, sound acquisition, and presentation systems. This fiscal year, we improved sound space recording methods using distributed spherical microphone arrays proposed in 2023. Moreover, we developed synthesis methods of near-field head-related transfer functions.

(3) Visual Cognition and Systems

(Aims) To understand the vision-related brain functions in order to apply the knowledge to realize human-oriented information communication systems.

(Achievements) In this year, our major achievements were the followings. 1) We revealed the brain mechanisms for attention adaptive to the varying spatial size with an EEG technique called SSVEP (steady-state visual evoked potential). We showed that attentional modulations are reflected as suppressive and enhanced brain signals. 2) We reported how emotional understanding is modulated by contextual factors such as gender and culture. By comparing the body movements and facial expressions of individuals from Japan and Taiwan, we apply psychophysical, mathematical modeling, and neurophysiological methods to separate these contextual influences.

(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 2024 are summarized as follows: (1) We reconstructed flexible swimming patterns of plesiosaurs by developing a swimming robot and a decentralized control mechanism, (2) we have proposed a decentralized control scheme for load-adaptive gaits of multi-legged robots inspired by millipedes, (3) we have designed a quadruped robot that has flexible body based on anatomical findings.

(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 2024 are as follows: (1) We formed hybrid membranes composed of lipids and Zn phthalocyanine on a gold substrate and investigated their optical properties, including quenching effects. (2) Using microfluidic devices, we realized artificial neuronal networks that exhibit diverse neuronal ensembles, i.e., a group of co-activated neurons. (3) We developed an electrochemiluminescence (ECL) imaging system for the evaluation of lipid membranes with different compositions.

(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) In this year, we primarily worked on exploring shape-changing inflatable robots for large-scale encountered-type haptics in cyber/virtual space (InflatableBots), a novel technique to provide endless handrail with haptic feedback from grounded objects using only a single user-following robot (LoopBot), a VR technology that allows you to draw large letters on a virtual canvas of infinite size using a drawing on a small desk (Redirected Drawing), and a XR Tooth-Cutting Training System with precise 3D measurement and manipulation technologies (VirtuEleDent).

(7) Soft Computing Integrated System

(Aims) We are working on a novel high-performance, highly-efficient, flexible, and robust brain-inspired brainmorphic computer hardware system, in particular, through physical complex-networked dynamical process using an analog VLSI as a core component.

(Achievements) 1) We evaluated closed-loop time-series prediction performance of the proposed extended chaotic neural network reservoir (eCNNR) showing superior performance with a small number of neurons. 2) We implemented an extended spatiotemporal contextual learning and memory network (eSTCLMN) as an event-driven asynchronous spiking neural network mixed analog/digital circuit using discrete circuit elements. As a result, we experimentally confirmed the feasibility of the hardware emulator for the eSTCLMN.

Electromagnetic Bioinformation Engineering

Communication with human body

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

[Research Target and Activities]

This laboratory developed a new synchronization method for measuring high-frequency magnetic fields using a pulse laser and magnetic garnet. They also improved the performance of magnetic garnet materials to develop new magnetooptical devices, potentially leading to the creation of devices that interact with living organisms and improve detection of unwanted electromagnetic waves.

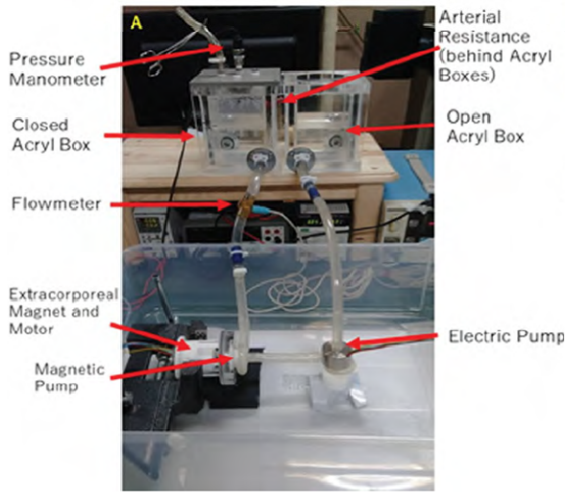


Fig. 1. Demonstration of an artificial heart. The operation of a prototype artificial heart was verified in a simulated human body environment.

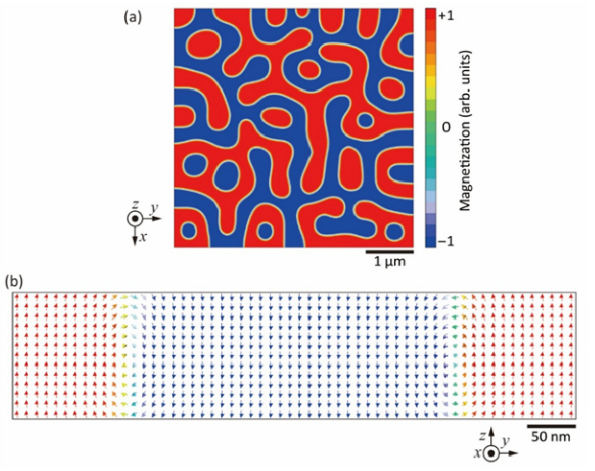


Fig. 2. Development of new magnetic materials for systems that capture electromagnetic field information using magnetism and light. The magnetic domain state was calculated using a supercomputer.

[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 magnetics device and materials.

[Papers]

[1] Taichi Goto, "Development of fabrication technique for microscopic transparent magnetic materials using local laser heating - Toward Stable Integrated Optical Modules for High-Speed Data Communication -", Journal of Japan Laser Processing Society, Vol. 32, pp. 37-39, 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.

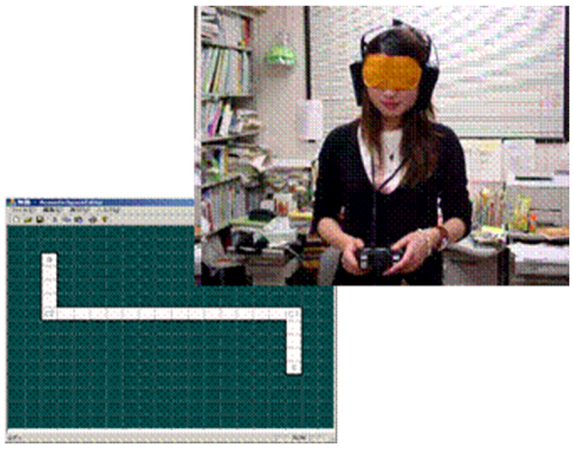


Fig. 1 Application for the training of spatial cognition using a high-definition virtual auditory display

In FY2024, we focused on the mechanism of auditory selective attention. The auditory selective attention plays a crucial rule in the cocktail party effect, which is well-known phenomenon as the mechanism for extracting target sounds from the surrounding auditory scene. This year, we investigated the directional dependency of hearing sensitivity in the horizontal plane for detecting changes, especially the sudden appearance or disappearance of a sound in the noisy situations. The results revealed no significant differences in the performance in all directions, suggesting that the sensitivity to detect changes would not depend on the direction[1]. Furthermore, we investigated an advanced sound field recording and reproduction method using distributed spherical microphone arrays based on kernel ridge regression[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 2016 to 2019, he was serving as a board member of the Acoustical Society of Japan.

[Papers]

[1] N. Kubo, S. Sakamoto, and M. Chait, “Direction dependence of detection rate of sound appearance/disappearance in noisy environments,” IEICE Technical Report, EA2024-39, 51-56 (2024).
[2] 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 (in press).
[3] K. Yanagiya and S. Sakamoto, “A study on the sound field reproduction method using distributed spherical microphone arrays based on infinite order analysis,” IEICE Technical Report, EA2024-49, 34-39 (2024).

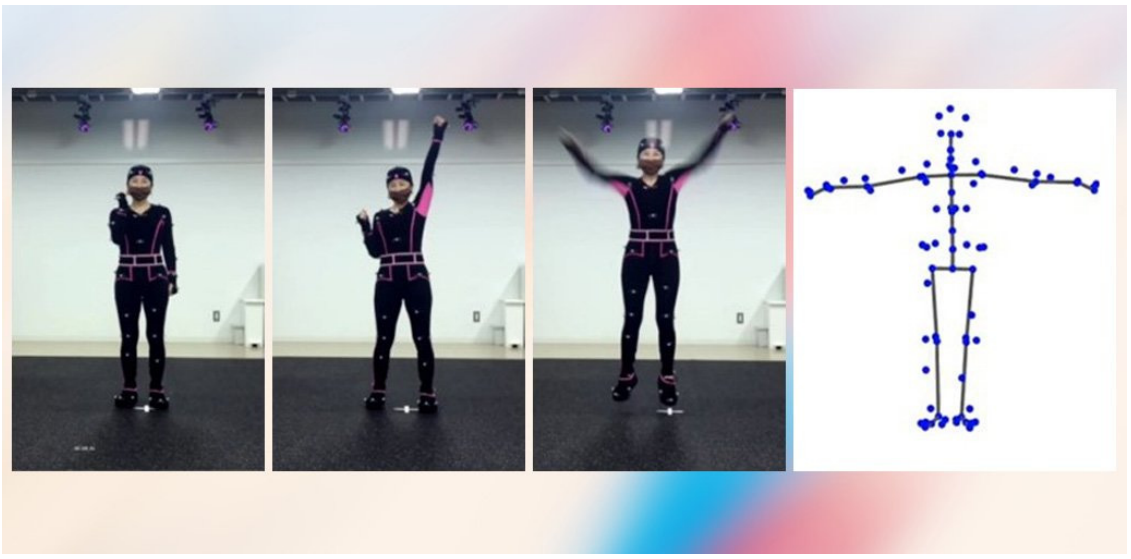
Contact to Professor SAKAMOTO Shuichi : shuichi.sakamoto.d5@tohoku.ac.jp

Visual Cognition and Systems Laboratory

Understanding human visual system for the better communication with visual information

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 2024, our major achievements were the followings.

1) Infant Bimodal Abstract Learning
We showed that infants learn more effectively with congruent visual-audio information, suggesting that crossmodal congruence matters for infant learning. This new principle implies that preverbal infants, similar to adults, are bounded by the perceptual relation from multiple senses prior to learning. This result directly challenges the most influential and well-accepted theory in infant multi-sensory learning (i.e. intersensory redundancy hypothesis, Bahrick & Lickliter, 2012) and provides a clear direction on how to improve it. As infant rule learning scaffolds a lot of development challenges later in life, our results pave the road for a new theory to capture the richness and complexity of infant learning ability.

2) Visual Understanding in 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 by recruiting professional performers to our lab. Their movements, recorded by a motion capture system (Vicon), were converted to dynamic point-light animations. An additional naïve observers viewed these animations and reported the perceived impression in an online experiment platform. We discovered that (1) naïve participants could judge the emotion from the movements well above chance, (2) Japanese participants are superior to detect negative expressions than the non-Japanese participants, and (3) observers have near-perfect performance to judge friendliness over hostility. We plan to investigate same-race advantage and cultural effects from this paradigm, and will continue to delineate the mechanisms in the future.

[Staff]

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

[Profile]

Chia-huei TSENG: She received her B.S. and B.M.S. from National Taiwan University and PhD from The University of California, Irvine, U.S.A. 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 as associate professor in 2016, she was a university professor in Taiwan and Hong Kong.

[Papers]

[1] Cheng, M., Tseng, C. H., Fujiwara, K., Higashiyama, S., Weng, A., & Kitamura, Y. (2025). Toward an Asian-based bodily movement database for emotional communication. *Behavior Research Methods*, *57*(1), 1-16.

[2] Yang, X., Cheng, M., Fujiwara, K., Kitamura, Y., Shioiri, S., Tseng, C. H. (2024). What Makes a Movement Human-Like? *Japanese Psychological Research*,66(4), 473-492.

[3] Chow, H.M. Ma, Y.K. Tseng, C. H. (2024). Social and Communicative not a Pre-requisite: Preverbal Infants Learn an Abstract Rule only from Congruent audio-visual dynamic pitch-height patterns. *Journal of Experimental Child Psychology*, 248, 106046.

[4] Hatori, Y., Yuan, Z. Tseng, C. H., Kuriki, I., & Shioiri, S. (2024). Modeling the Dynamics *of* Contextual Cueing Effect by Reinforcement Learning. *Journal of Vision*, *24*(12), 11-11

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.

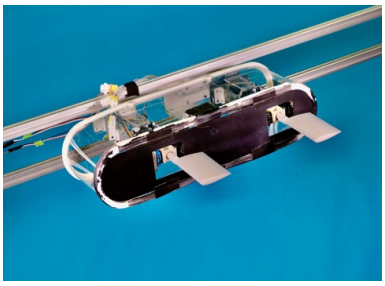


Fig.1: Plesiosaur-inspired flipper robot, PercyBot.

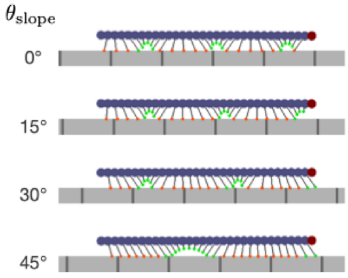


Fig.2: Millipede-inspired walking control reproducing gait transition in response to the inclination level of the ground.

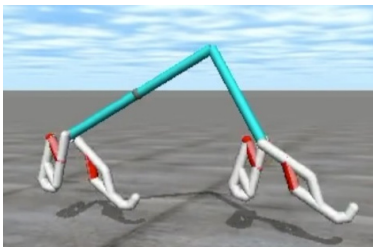


Fig.3: Quadurped robot with bicycle-inspired simple balance control

[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.

[Papers]

[1] Fukuhara, A., Sato, M., Ogawa, H. *et al.* Rethinking the four-wing problem in plesiosaur swimming using bio-inspired decentralized control. *Sci Rep* **14**, 25333 (2024). https://doi.org/10.1038/s41598-024-55805-z

[2] Yasui, K., Ohno, A., Kano, T., Ishiguro, A. Decentralized control law for load-adaptive gaits of multi-legged robots inspired by millipedes. *Advanced Robotics*, ***39***, 79-88 (2025). https://doi.org/10.1080/01691864.2024.2408619

[3] Hattori, S., Suzuki, S., Fukuhara, *et al.*, A. Bicycle-inspired simple balance control method for quadruped robots in high-speed running. *Frontiers in Robotics and AI*, **11**, 1473628 (2025). https://doi.org/10.3389/frobt.2024.1473628

Nano-Bio Hybrid Molecular Devices

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

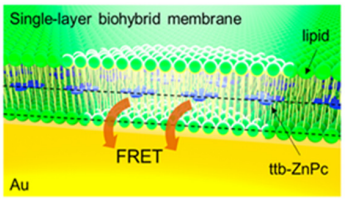
Nano-Bio Hybrid Molecular Devices: Ayumi Hirano-Iwata, Professor

[Research Target and Activities]

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

1. Fluorescence properties of lipid membranes containing Zn phthalocyanine

We formed large hybrid membranes composed of lipids and Zn phthalocyanine on a gold substrate and investigated their optical properties. Since the phthalocyanine complex and the gold substrate were separated by a lipid monolayer, the photoexcited complexes transferred the absorbed energy to the gold, causing the fluorescence to quench. This unique property of the hybrid membranes could be utilized in a variety of optoelectronic applications.[1]



Hybrid membrane of lipids and Zn phthalocyanine

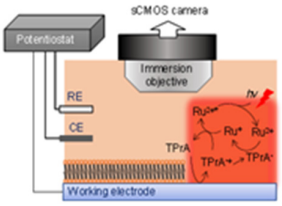
2. Engineering living neuronal networks using microfluidic devices

By patterning cultured rat cortical neurons using microfluidic devices, we realized artificial neuronal networks that exhibit diverse neuronal ensembles, i.e., a group of co-activated neurons. Moreover, we showed that repeated optogenetic stimulation modulates these ensembles, suggesting a process that resembles a simple form of network plasticity in cultured neurons.[2]

Functional control of neuronal networks

3. Electrochemiluminescence imaging for lipid membrane studies

We developed an electrochemiluminescence (ECL) imaging system for the evaluation of lipid membranes. With the ECL reaction between $[Ru(bpy)_3]^{2+}$ and tri-*n*-propylamine, different compositions of lipid membranes could be distinguished based on differences in the onset potential and luminescence intensity[3]. Furthermore, we tracked the membrane disruption process induced by the antimicrobial peptide melittin on the lipid membranes using the ECL imaging[4].



Electrochemiluminescence imaging of lipid membranes

[Staff]

Professor: Ayumi Hirano-Iwata, Dr.
Assistant Professor: Daisuke Tadaki, Dr.
Assistant Professor: Maki Komiya, Dr.
Assistant Professor: 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.

[Papers]

[1] T. Ma, K. Watabe, M. Komiya, K. Hiramoto, X. Feng, D. Tadaki, A. Hirano-Iwata, "Optical properties of ultrathin biohybrid membranes: implications for ooptoelectronic applications", *ACS Appl. Nano Mater.*, **7**, 18379-18385 (2024).

[2] H. Murota, H. Yamamoto, N. Monma, S. Sato, A. Hirano-Iwata, "Precision microfluidic control of neuronal ensembles in cultured cortical networks", *Adv. Mater. Technol.*, **10**, 2400894 (2025).

[3] K. Hirmaoto, A. Hirano-Iwata, K. Ino, H. Shiku, "Electrochemiluminescence of $[Ru(bpy)_3]^{2+}$/tri-*n*-propylamine to visualize different lipid compositions in supported lipid membranes", *Chem. Commun.*, **61**, 4495–4498 (2025).

[4] K. Hiramoto, K. Ino, I. Takahashi, A. Hirano-Iwata, H. Shiku, "Electrochemiluminescence microscopy for the investigation of peptides interactions within planar lipid membranes", *Faraday Discuss.*, **257**, 137–150 (2024).

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

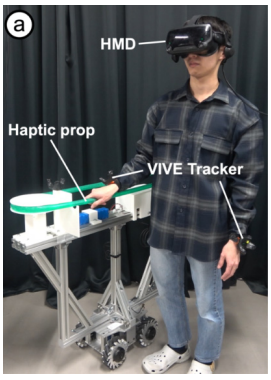
Interactive Content

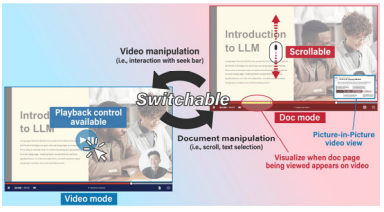
Technologies for Interactive Content

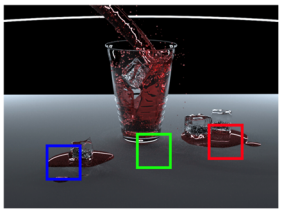
Interactive Content Design, Yoshifumi KITAMURA, Professor
Human-Workspace Interaction, Kazuyuki FUJITA, Associate Professor

[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 a user-following robot that provides haptic feedback of large grounded objects in room-scale VR, a compact XR tooth drilling training system using a 3D trackable handpiece, a user interface for presentation videos of documents that integrates video viewer and document viewer into one screen, and an online framework to learn the spatial-varying distribution of the full product of the rendering equation.

[Staff]

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

[Papers]

[1] Jiawei Huang, Akito Iizuka, Hajime Tanaka, Taku Komura, Yoshifumi Kitamura, Online Neural Path Guiding with Normalized Anisotropic Spherical Gaussians, ACM Transactions on Graphics, 43, 3, April 2024

[2] Gomi Ryota, Ryo Suzuki, Kazuki Takashima, Kazuyuki Fujita, Yoshifumi Kitamura, InflatableBots: Inflatable Shape-Changing Mobile Robots for Large-Scale Encountered-Type Haptics in VR, Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems (CHI '24), Article No. 423, pp. 1-14, May 2024

[3] Taichi Murakami, Kazuyuki Fujita, Kotaro Hara, Kazuki Takashima, Yoshifumi Kitamura, SwapVid: Integrating Video Viewing and Document Exploration with Direct Manipulation, Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems (CHI '24), Article No. 1035, pp. 1-13, May 2024

[4] Kumpei Ogawa, Kazuyuki Fujita, Shuichi Sakamoto, Kazuki Takashima, Yoshifumi Kitamura, Exploring Visual-Auditory Redirected Walking using Auditory Cues in Reality, IEEE Transactions on Visualization and Computer Graphics, Volume 30, Issue 8, pp. 5782-5794, August 2024

[5] Xiaoyue Yang, Miao Cheng, Ken Fujiwara, Yoshifumi Kitamura, Satoshi Shioiri, Chiahuei Tseng, What Makes a Movement Human-Like?, Japanese Psychological Research, August 2024

[6] Tetsushi Ikeda, Kazuyuki Fujita, Kumpei Ogawa, Kazuki Takashima, Yoshifumi Kitamura, LoopBot: Representing Continuous Haptics of Grounded Objects in Room-scale VR, Proceedings of the 37th Annual ACM Symposium on User Interface Software and Technology (UIST '24), Article No. 135, pp. 1-10, October 2024

[7] Miao Cheng, Chiahuei Tseng, Ken Fujiwara, Shoi Higashiyama, Abby Weng, Yoshifumi Kitamura, Toward an Asian-based bodily movement database for emotional communication, Behavior Research Methods, 57(1), pp.1-16, January 2025

[8] Yuhui Wang, Kazuki Takashima, Kazuyuki Fujita, Hong Guang, Yoshifumi Kitamura, VirtuEleDent: A Compact XR Tooth-Cutting Training System Using a Physical EMR-based Dental Handpiece and Teeth Model., 2025 IEEE Conference Virtual Reality and 3D User Interfaces (VR), pp.749-758, March 2025

[9] Kumpei Ogawa, Kazuyuki Fujita, Kazuki Takashima, Yoshifumi Kitamura, Redirected Drawing: Expanding the Perceived Canvas Size in VR, Proceedings of the 2025 IEEE Conference on Virtual Reality and 3D User Interfaces (VR), pp. 494-504, March 2025

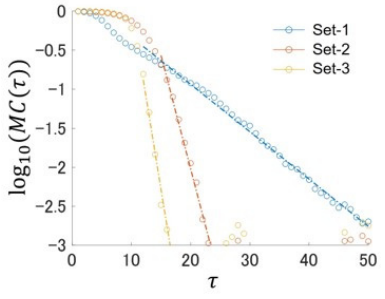
Soft Computing Integrated System

Brainmorphic Computing Hardware System

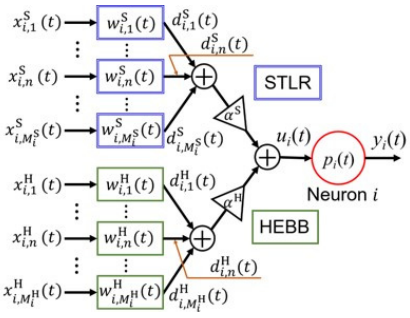
Soft Computing Integrated System Yoshihiko Horio, Professor

[Research Target and Activities]

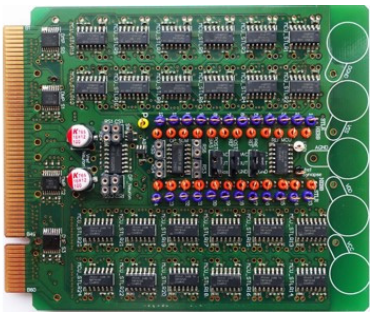
We are working on a "brainmorphic" computing hardware (BMCHW) system, and developing integrated circuit and device technologies suitable for BMCHW. During the FIY 2023; 1) We proposed a prospective neuron model with self-feedbacks of its internal state and output. We then applied the proposed model to the reservoir neurons or output neurons in a reservoir neural network. Through simulations, we showed the effectiveness of the prospective neurons. 2) We proposed an extended spatiotemporal contextual learning and memory network (eSTCLMN) model for an event-driven spiking neural network hardware. We also proposed a Hamming distance histogram and a multi-stage 2D map technique for evaluation of learning performance of the eSTCLMN model. We built a prototype circuit for eSTCLMN using discrete circuit elements.



Memory capacity characteristics of the proposed prospective reservoir.



Neuron in the eSTCLMN model.



Prototype of the eSTCLMN.

[Staff]

Professor : Yoshihiko Horio, Ph.D.
Specially Appointed Assistant Professor : Takemori Orima, Dr.
Technical Assistants : Mariko Takahashi and Chikako Hibino

[Profile]

Yoshihiko Horio received the Ph.D. degree from Keio University in 1987. He is currently a Professor with the Research Institute of Electrical Communication, Tohoku University. From 1987 to 2016, he was with Department of Electronic Engineering, Tokyo Denki University being a Professor from 2000. From 1992 to 1994, he was a Visiting Professor at Center for Telecommunications Research, Columbia University, U.S.A. His current research interests are in the area of neuromorphic and brainmorphic hardware systems and brain-inspired VLSI systems. Dr. Horio is a Fellow of the IEICE, and Emeritus Professor of Tokyo Denki University.

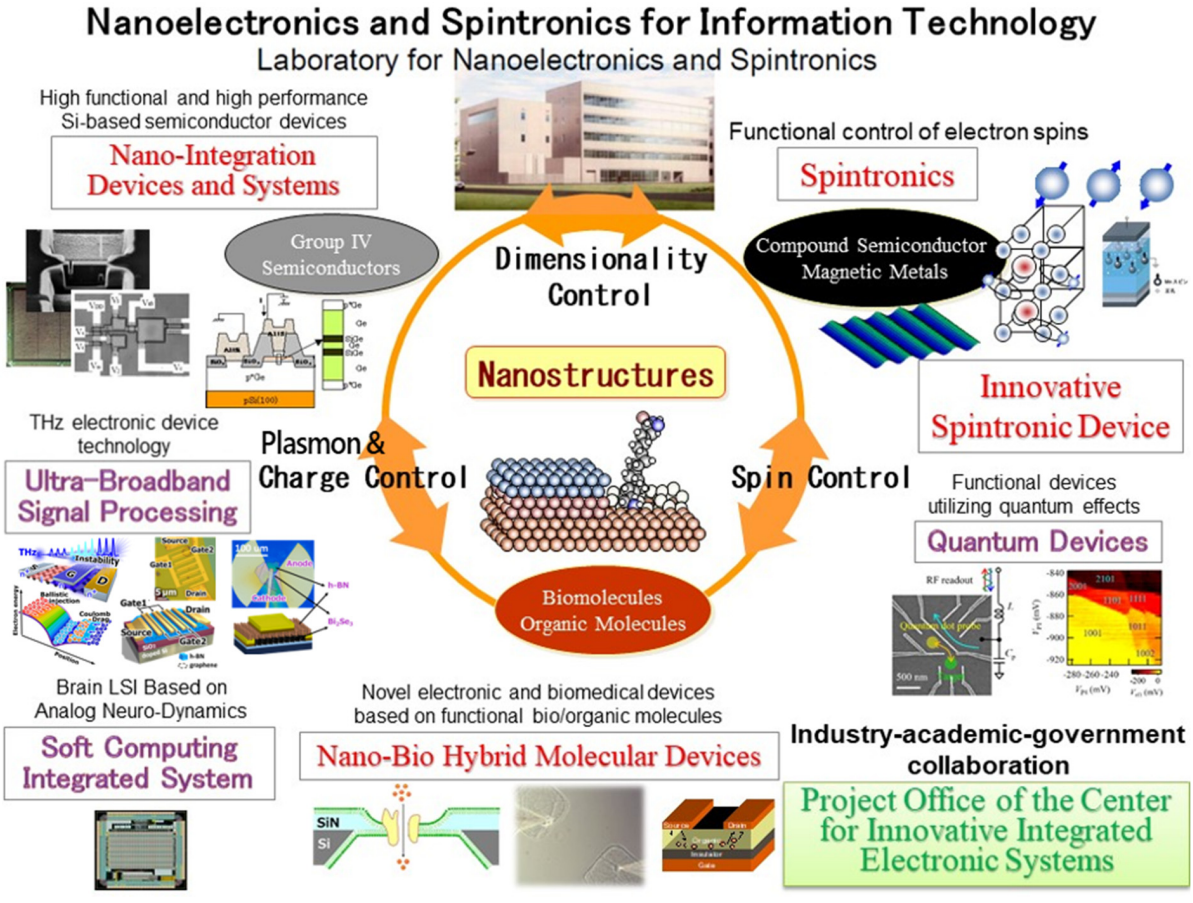
[Papers]

[1] T. Orima, T. Tsuji, and Y. Horio, "An extended spatiotemporal contextual learning and memory network model for hardware implementation," Procedia Computer Science, vol. 222, pp. 478-487, 2023. DOI: 10.1016/j.procs.2023.08.186
[2] Go Ishii, Yoshihiko Horio, and Takemori Orima, "Effect of memory capacity characteristics on time-series prediction in reservoir neural network consisting of neurons with local temporal history," in Proc. KJCCS, BP-6, 2024. (Best Student Paper Award).
[3] T. Tsuji, T. Orima, and Y. Horio, "Detailed evaluation of spatiotemporal learning rule based on Hamming distances among output vectors," in Proc. NOLTA, pp. 415-418, 2023.

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, and Nano-Bio Hybrid Molecular Devices; together with the project office of the Center for Innovative Integrated Electronic Systems, and the groups of Ultra-Broadband Signal Processing, Soft Computing Integrated System 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 2024 are shown below.

Nano Integration

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

(1) We evaluated the performance of a reservoir computing system using a spiking neural network (SNN) capable of operating with extremely low power consumption. Through applications to tasks such as speech recognition, we demonstrated that the system operates with approximately 1/100th the power consumption compared to conventional digital circuits, thereby highlighting its potential for edge computing applications.

(2) We found that voltage shifts suggesting two types of charge injection and trapping occurred in MOS capacitors fabricated by thermally oxidizing an a-Si film on a 4H-SiC substrate. Furthermore, we successfully confirmed clear differences in the formation of accumulation and depletion layers in MOS capacitors fabricated in each region on a 3C-SiC/4H-SiC hybrid substrate. (3) We developed microfluidic devices that enable simultaneous control of connection directionality and modular structure in cultured neuronal networks and found that embedding directionality in intermodular connections diversifies spontaneous activity patterns.

(3) We developed microfluidic devices that enable simultaneous control of connection directionality and modular structure in cultured neuronal networks and found that embedding directionality in intermodular connections diversifies spontaneous activity patterns. Furthermore, we theoretically analyzed the underlying mechanisms using spiking neural networks and state transition models.

● Soft Computing Integrated System (Y. Horio)

We are working on a novel high-performance, highly efficient, flexible, and robust brain-inspired brainmorphic computer hardware system, in particular, through physical complex-networked dynamical process using an analog VLSI as a core component. Results for this year are summarized as follows:

(1) We investigated the time series prediction performance of an extended chaotic neural network reservoir model with expanded parameter ranges for chaotic neural network models, and experimentally demonstrated that prediction performance improves significantly even with a small number of neurons. Furthermore, we clarified that the mechanism behind the performance improvement stems from the exponential decay characteristic of memory capacity with respect to time delay. Additionally, we discussed the relationship with predictive neurons, which have recently been confirmed physiologically. These findings are important contributions that will greatly contribute to the realization of low-cost, high-performance hardware.

(2) We implemented an extended spatiotemporal sequence context learning and memory network, described as a differential/difference equation of continuous time and continuous values, as an event-driven spiking neural network learning circuit system using analog/digital hybrid circuits with discrete components, and confirmed its effectiveness through spike sequence learning experiments. This enables the implementation of an

emulator for pre-determining circuit parameters during integrated circuit design. Additionally, considering implementation in integrated circuits, simulation experiments revealed that the system exhibits high learning performance when the ratio of excitatory to inhibitory synapses is 8:2 to 9:1.
(3) We integrated a modified Izhikevich spiking neuron model into an integrated circuit and experimentally confirmed chaotic spike train waveforms, spike interval bifurcation diagrams, and chaotic attractors. Furthermore, we applied the chaotic spike trains obtained from this integrated circuit to an extended spatiotemporal sequence context learning and memory network, demonstrating the effectiveness of chaotic spike trains.
(4) We summarized the theory and hardware foundation technologies of the brainmorphic computing hardware paradigm. Furthermore, by incorporating event-driven asynchronous spiking neural networks for spatiotemporal information representation and processing into the existing brainmorphic computing framework, we extended it to a hardware computing paradigm that is more closer to the brain.

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) "Quantum metric"—which corresponds to a kind of "universe" of the electronic quantum states—was successfully controlled at room temperature and under low magnetic fields, in a multilayer structure composed of noncollinear antiferromagnetic Mn_3Sn and platinum; (2) temperature dependence of the time-domain and time-averaged characteristics of superparamagnetic magnetic tunnel junctions are measured, and the underlying physical mechanisms were elucidated; (3) a double-free-layer superparamagnetic magnetic tunnel junction whose characteristics are expected to be insensitive to bias voltage was fabricated and its suitability for probabilistic bit (p-bit) applications was confirmed; (4) defects in spinels—known as gemstones and also used as tunnel barrier materials in spintronic devices—were found to have a function of quantum bits; (5) the mechanism by which large output signals can be obtained in magnetic tunnel junctions that harvest energy from radio waves used in wireless communications was clarified and a proof-of-concept for energy harvesting was demonstrated; (6) efficiency to control the magnetization using non-equilibrium flows of orbital angular momentum and spin angular momentum was compared and their differences in characteristics for device applications were revealed; (7) Gaussian random numbers—used extensively in diffusion models for generative AI—were found to be generated with ultra-low power consumption by spintronic devices operating stochastically through thermal fluctuations; (8) mutual control between a noncollinear antiferromagnetic Mn_3Sn and ferromagnetic CoFeB was demonstrated in their multilayer structure and basic operations for reconfigurable and neuromorphic devices were demonstrated; (9) spin Hall magnetoresistance in a multilayer structure composed of

noncollinear antiferromagnetic Mn_3Sn and platinum was observed and the torque with a symmetry different from conventional cases was found to dominantly contribute to the effect in the noncollinear antiferromagnet.

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

The goal of our research is to explore the terahertz frequency range by creating novel integrated electron devices and circuit systems. III-V- and graphene-based active plasmonic heterostructures for creating new types of terahertz lasers and ultrafast transistors 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 2024 FY.

1. Development of rectenna diode THz detector with topological Dirac semimetallic Bi_2Se_3

We have fabricated topological semimetallic Bi_2Se_3 films, in which electrons and holes behave as asymmetric relativistic Dirac particles, by liquid phase growth and fabricated them as tunnel rectenna diodes. We have successfully demonstrated asymmetric photoresponse properties reflecting asymmetric Dirac dispersion of Bi_2Se_3 fermions, and fast non-energy-consumption, non-biased THz wave detection thanks to its asymmetric dispersive nature, which is difficult to achieve with graphene materials. (2 international peer-reviewed proceedings; 3 invited talks at international conferences).

2. Development of photonics-electronics convergence mixers

To realize the carrier frequency down-conversion from optical to wireless data signals, which is one of key technologies in future photonics-electronics convergence networks, we have developed photonic double-mixers based on field-effect transistors. In this fiscal year, we achieved the conversion gain of -72 dB for the 300-GHz-band carrier frequency down-conversion using a photonic double-mixer based on an InGaAs-channel high-electron-mobility. Furthermore, we succeeded in the first demonstration of 1-THz-band carrier frequency down-conversion using a graphene-channel field-effect transistor.

● **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 2024 are as follows.

(1) We developed electronic measurement and control methods for local electronic states in nanostructures utilizing semiconductor quantum dots. We improved the methods using informatics approaches and new materials.

(2) We measured local electronic and spin states in nanostructures using sensitive electronic measurement techniques. We revealed the local electronic states in nanostructures and in new materials.

(3) We studied semiconductor quantum devices and systems for quantum information processing. We investigated the analysis and control of quantum states, and developed techniques for scaling up the systems and creating devices based on new 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) We formed large hybrid membranes composed of lipids and Zn phthalocyanine on a gold substrate and investigated their optical properties. Since the phthalocyanine complex and the gold substrate were separated by a lipid monolayer, the photoexcited complexes transferred the absorbed energy to the gold, causing the fluorescence to quench. This unique property of the hybrid membranes could be utilized in a variety of optoelectronic applications.

(2) By patterning cultured rat cortical neurons using microfluidic devices, we realized artificial neuronal networks that exhibit diverse neuronal ensembles, i.e., a group of co-activated neurons. Moreover, we showed that repeated optogenetic stimulation modulates these ensembles, suggesting a process that resembles a simple form of network plasticity in cultured neurons.

(3) We developed an electrochemiluminescence (ECL) imaging system for the evaluation of lipid membranes. With the ECL reaction between $[Ru(bpy)_3]^{2+}$ and tri-*n*-propylamine, different compositions of lipid membranes could be distinguished based on differences in the onset potential and luminescence intensity[]. Furthermore, we tracked the membrane disruption process induced by the antimicrobial peptide melittin on the lipid membranes using the ECL imaging

Research Targets and Activities of Laboratory for Brainware Systems

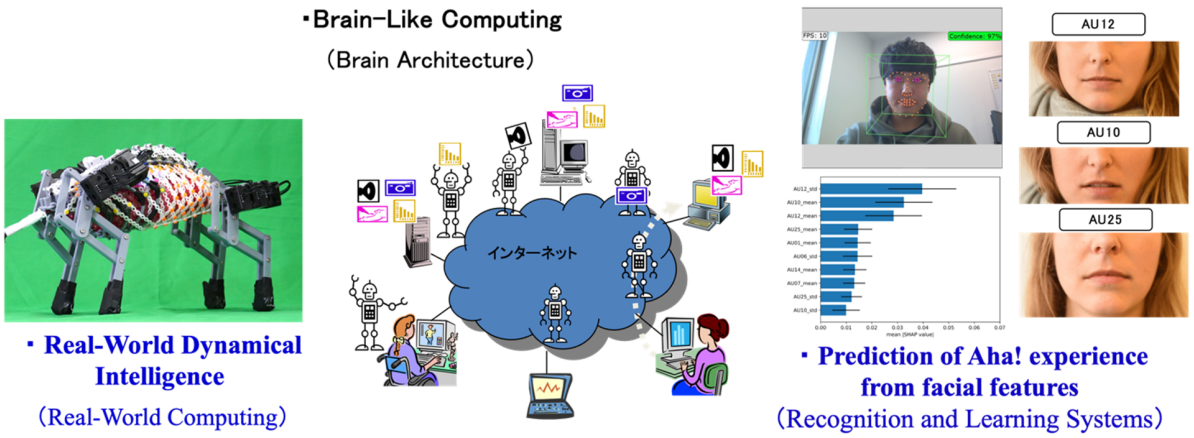
The Laboratory for Brainware Systems of the Research Institute of Electrical Communication was established in 2004 and renewed in 2014. Its purpose is to contribute to the research and development of advanced information science and technology for Brainware systems which realize a seamless fusion of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

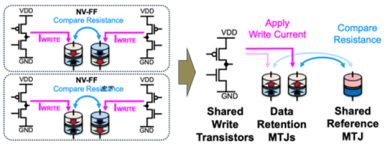
Seamless Fusion of Real World and Multi-Modal Computing



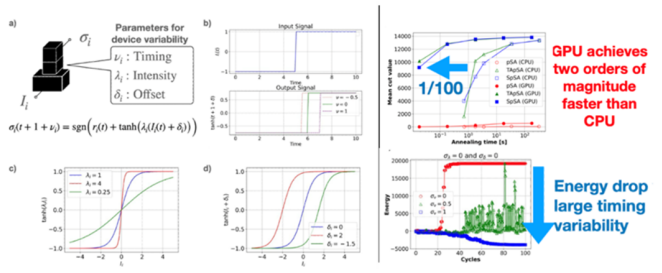
・ **Real-World Dynamical Intelligence**
(Real-World Computing)

・ **Prediction of Aha! experience from facial features**
(Recognition and Learning Systems)

Hardware Environment with Massively Parallel Brain LSI



	Conventional	Proposed
MTJ Devices	64	48
Backup Time	30 ns	240 ns
Backup Energy	0.44 nJ -50.0%	0.22 nJ
Cell Area	871 um² -44.2%	486 um²



・ **Novel MTJ-based NV-FF circuitry**

・ **Fast Solving Larger Combinatorial Opt. Problem**

(New Paradigm VLSI System)

[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.

Soft Computing Integrated System Section: We are working on a novel high-performance, highly-efficient, flexible, and robust brain-inspired brainmorphic computer hardware system, in particular, through physical complex-networked dynamical process using an analog VLSI as a core component. Toward the final goal, we are developing integrated circuit and device technologies suitable for the brainmorphic computer systems. We further intend to realize an autonomous brain-inspired computer with a sense of self and consciousness based on dynamic and complex changes in spatiotemporal network state and structure.

[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 2024 are an important step towards the goal as:

--Real-World Computing Section has proposed a decentralized control mechanism for adaptive swimming patterns of an extinct-animal-inspired robot.
https://doi.org/10.1038/s41598-024-55805-z

--New Paradigm VLSI System Section has proposed an energy-efficient non-volatile register with write-operation probability. This is a pioneering achievement for intermit computing of IoTs."
https://doi.org/10.1109/ACCESS.2025.3546590

--Recognition and Learning Systems section has reported the size tuning of visual spatial attention
https://jov.arvojournals.org/article.aspx?articleid=2802941

-- Soft Computing Integrated System Section has confirmed superior performance of an extended chaotic network reservoir, and has clarified the mechanism of its improvement.
https://doi.org/10.1587/nolta.15.750

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)

Soft Computing Integrated System Section:
(refer to Soft Computing Integrated System 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 create computational models of the process that the human brain integrates multiple sensory inputs from the outside world, we are investigating the visual and auditory functions in the human brain for implementing these functions in hardware under biologically plausible settings. Our approaches include psychophysics, brain wave measurements, and computer simulations.

This year, first, we investigated the size tuning of visual spatial attention using steady-state visual evoked potential (SSVEP) to understand how visual attention efficiently adapts and directs to specific spatial extents. Analysis of SSVEP amplitudes and intertrial phase coherence revealed that visual attention exhibited size tuning with the maximum attentional modulation when the attended size matched the stimulus size. A difference of Gaussian function effectively modeled the facilitation around the attended size and inhibition for adjacent sizes. These findings suggest that visual attention can precisely adjust its focus to enhance processing efficiency, aligning with the zoom lens hypothesis. Our SSVEP study provides strong neural evidence underlying the adaptability of visual attention to varying spatial demands.

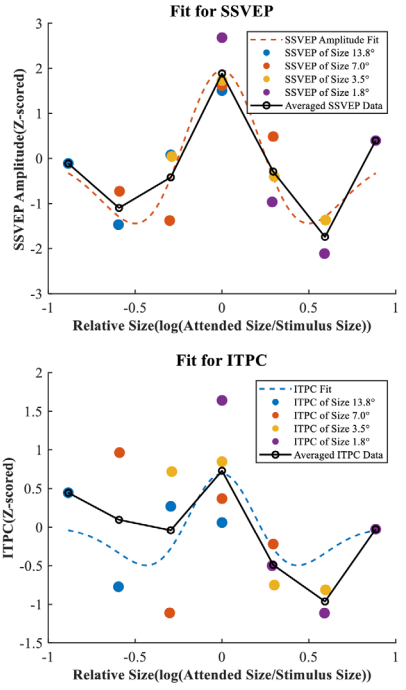


Fig. 1: Amplitude (top) and intertrial phase coherences (bottom) as a function of relative size.

Seconds, we investigated the mechanism of selective attention. In the experiment, we measured the detection performance of sound appearances/disappearance in every 12 directions (30-degree intervals). At the same time, we measured the pupil diameter changes induced by the sound appearances in every 6 directions (60-degree intervals). The results revealed no significant differences in the performance and the pupil diameter change in all directions, suggesting that the sensitivity to detect changes would not depend on the direction.

[Staff]

Professor: Shuichi Sakamoto, Ph.D.

[Papers]

[1] G. Chen, Y. Hatori, C.-H. Tseng, S. Shioiri, “Adaptive focus: Investigating size tuning in visual attention using SSVEP,” Journal of Vision, 25(6), pp.1-15 (2025).

[2] N. Kubo, S. Sakamoto, and M. Chait, “Direction dependence of detection rate of sound appearance/disappearance in noisy environments,” IEICE Technical Report, EA2024-39, 51-56 (2024).

[3] 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 (in press).

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 devisions, "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, Leader, Professor
Takashi Shiba, Specially Appointed Professor
Satoshi Tsukamoto, Specially Appointed Professor
Satoko Itaya, Visiting Professor
Mizuki Motoyoshi, Visiting Associate Professor
Takashi Mehata, Visiting Associate Professor
Tamotsu Nishino, Research Fellow

Interdisciplinary Collaboration Research Division

Challenging and Exploratory Research Division
Shuichi Sakamoto, Project Leader, Professor
Yoshifumi Kitamura, Project Leader, Professor
Noriharu Suematsu, Project Leader, Professor

Contact to Professor SUEMATSU Noriharu : noriharu.suematsu.a3@tohoku.ac.jp

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

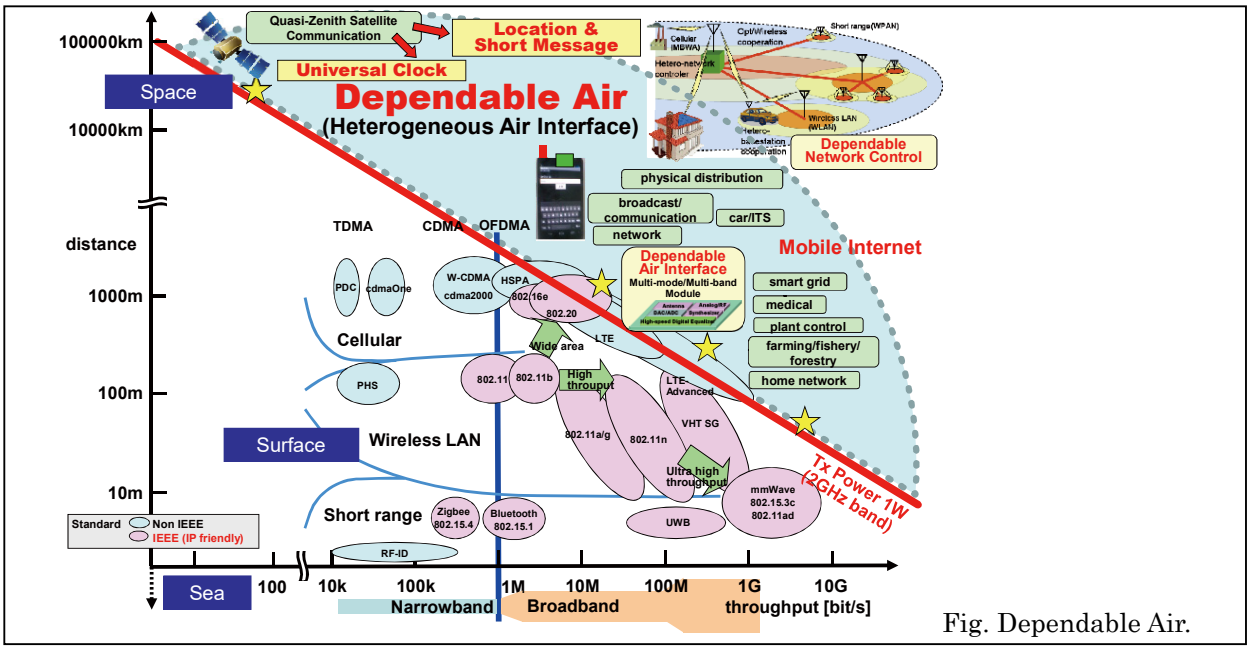


Fig. Dependable Air.

[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]

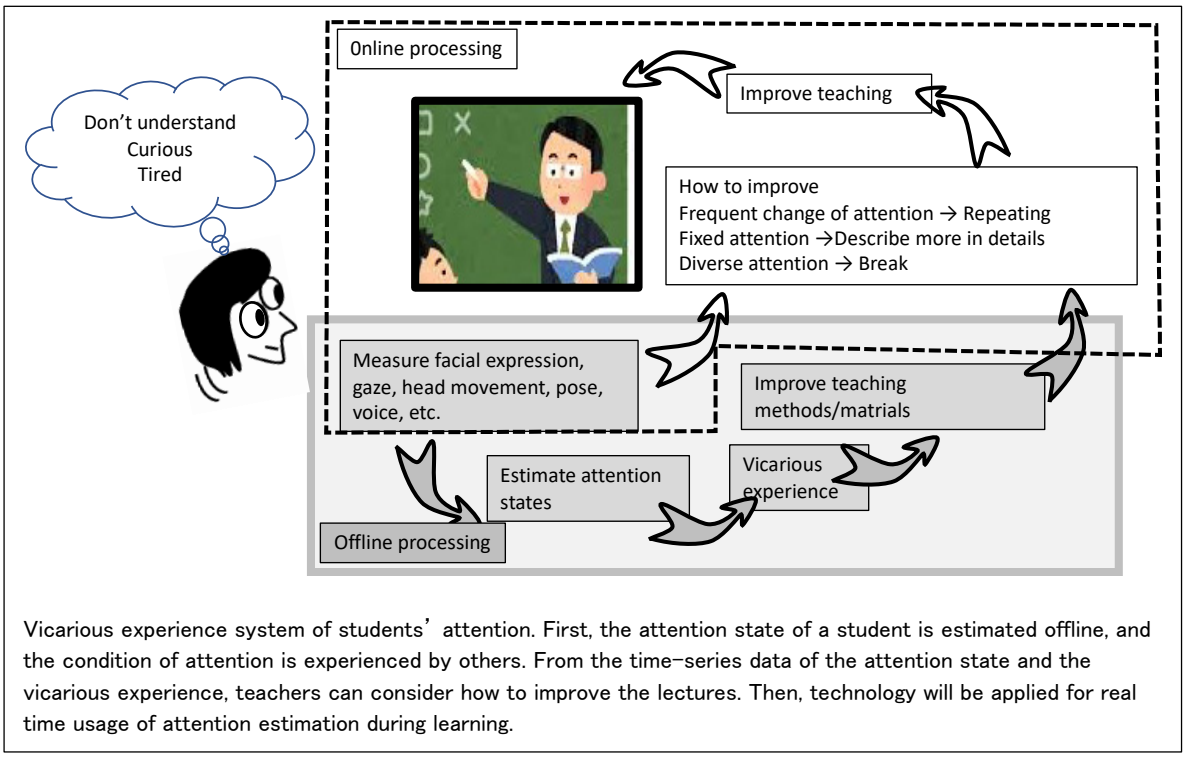
Professor: Noriharu Suematsu, Ph.D
Specially Appointed Professor: Takashi Shiba, Ph.D
Specially Appointed Professor: Satoshi Tsukamoto, Ph.D
Researcher: Tamotsu Nishino, Ph.D

[Papers]

[1] T. Shiba et al., "Proposal of Channel Model Measurement Method Under Local 5G System Operation," 2024 IEEE VTS Asia Pacific Wireless Communications Symposium (APWCS), Singapore, 2024.
[2] N. Suematsu, T. Furuichi and S. Tsukamoto, "Q/V-Band Distributed Scalable DBF Antenna with Direct Digital Transceiver for LEO Constellation Satellites," 2025 IEEE Space Hardware and Radio Conference (SHaRC), San Juan, PR, USA, 2025.

Exploratory Research Division

Development of the education support system
with estimation of attention states



Vicarious experience system of students' attention. First, the attention state of a student is estimated offline, and the condition of attention is experienced by others. From the time-series data of the attention state and the vicarious experience, teachers can consider how to improve the lectures. Then, technology will be applied for real time usage of attention estimation during learning.

[Research Target and Activities]

Fostering creativity is a significant and important component of education. Although research on mental processes of insight, which is a critical component of creativity, has attracted much attention, our understanding of the processes involved in creativity is limited. In order to understand the brain function or the mental process of insight, or Aha!, we measured the EEG and facial expressions of subjects while they completed a quiz task that required inspiration used for insight. Trials were divided into two groups, one in which they reported Aha! and the other in which they did not. Then, machine-learning models were formed to classify them based on their EEG and facial expressions. Since facial features played larger contribution for the classification, facial expressions may be more strongly related to Aha! than EEG..

[Staff]

Shuichi Sakamoto, Project Leader, Professor
Satoshi Shioiri, Former Project Leader, Emeritus Professor

[Profile]

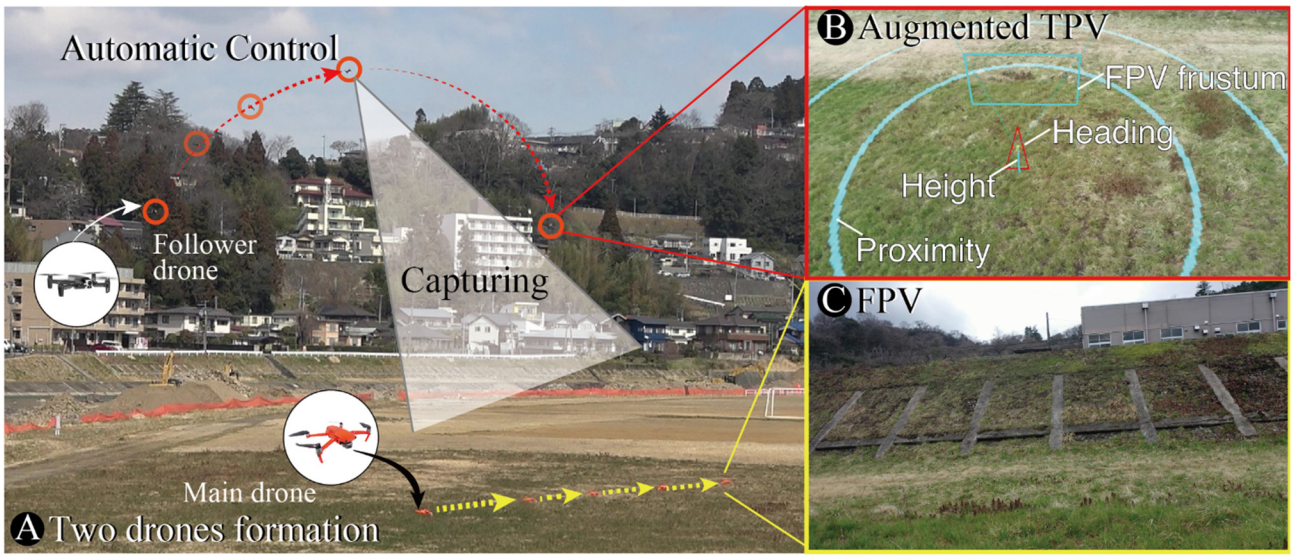
Shuichi Sakamoto graduated from Tohoku University in 1997 and received his Ph. D. degree in 2004 also from Tohoku University. His research interests include human auditory and multisensory information processing and development of advanced multimodal information systems. From 2016 to 2019, he was serving as a board member of the Acoustical Society of Japan.

[Papers]

[1] Predicting learners' engagement and help-seeking behaviors in an e-learning environment by using facial and head pose features, GY Wang, Y Hatori, Y Sato, CH Tseng, S Shioiri, Computers and Education: Artificial Intelligence, 1003871 (2025)
[2] 顔表情データによる洞察予測における,被験者内・間予測の比較と考察 , 明戸浩志, 羽鳥康裕, 佐藤好幸, 曾加恵、 塩入諭, Vision 36(1) 2024 年

Exploratory Research Division

Interactive Drone Content for Entertainment / Wildlife Symbiosis



BirdViewAR overview with two drone formations

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

[Main Results for FY2024]

We propose BirdViewAR, a surroundings-aware remote drone-operation system that provides significant spatial awareness to pilots through an augmented third-person view (TPV) from an autopiloted secondary follower drone. The follower drone responds to the main drone's motions and directions using our optimization-based autopilot, allowing the pilots to clearly observe the main drone and its imminent destination without extra input. To improve their understanding of the spatial relationships between the main drone and its surroundings, the TPV is visually augmented with AR-overlay graphics, where the main drone's spatial statuses are highlighted: its heading, altitude, ground position, camera field-of-view (FOV), and proximity areas. A full paper on the results was accepted for ACM CHI 2023, the top international conference on human-computer interaction, and was orally presented in May 2023 [1]. This content was also introduced on the Internet news and presented as invited talks at two domestic conferences in 2024.

[Staff]

Professor: Yoshifumi Kitamura, Dr.

[Profile]

Yoshifumi Kitamura: Since 2010, Yoshifumi Kitamura has been Professor in the Research Institute of Electrical Communication, Tohoku University. Prior to arriving at Tohoku, he was an Associate Professor at Graduate School of Engineering, and Graduate School of Information Science and Technology, Osaka University. While working at ATR Communication Systems Research Laboratories, he focused on sophisticated user interfaces in virtual environments. His first formal appointment was in the Information Systems Research Center Canon Inc., where he was involved in research on artificial intelligence, image processing, computer vision, and 3D data processing. His formal education was obtained at Osaka University, B.Sc (1985); M.Sc. (1987); and Ph.D. (1996).

[Papers]

[1] Maakito Inoue, Kazuki Takashima, Kazuyuki Fujita, Yoshihumi Kitamura. BirdViewAR: Surroundings-aware Remote Drone Piloting Using an Augmented Third-person Perspective, Proc of the Conference on Human Factors in Computing Systems (CHI), Article No. 31, April 2023.

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

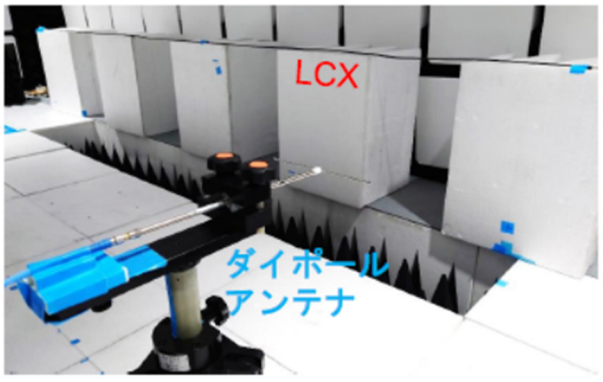


Fig.1: Leaky coaxial cable (LCX)

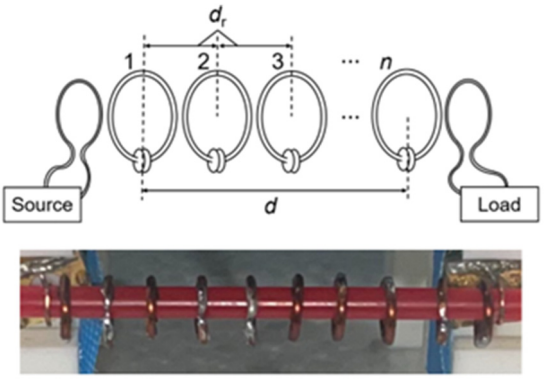


Fig.2: Wireless sensor network experiment using sub-cm domino resonators

[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 LCX communication evaluation setup system for smart factories. We evaluated the effect of shadowing in a situation where a metal obstacle (e.g. wall) is placed near the antenna and LCX placement conditions. Fig.2 shows wireless sensor network experiment using sub-cm domino resonators which will be integrated with sensors of high dense electroencephalography (EEG) for BMI.

[Papers]

[1] E. Nagahari, T. Furuichi, T. Shiba and N. Suematsu, "Radiation Characteristics of 2.4GHz-Band Wi-Fi LCX Antenna with Varying Cable Rotation Angle and Distance from Metal Wall," 2024 IEEE Asia-Pacific Microwave Conference (APMC), Bali, Indonesia, 2024.

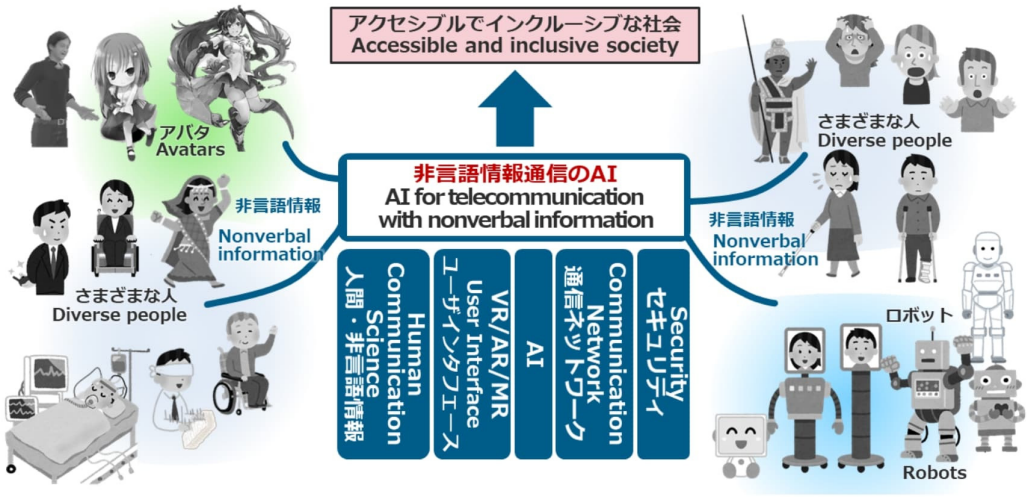
[2] F. Wakiya, T. Furuichi and N. Suematsu, "Sub-cm-size 2-GHz Domino-Resonator Wireless Transmission," 2024 IEEE Asia-Pacific Microwave Conference (APMC), Bali, Indonesia, 2024, pp. 584-586.

Interdisciplinary ICT Research Center for Cyber and Real Space

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.

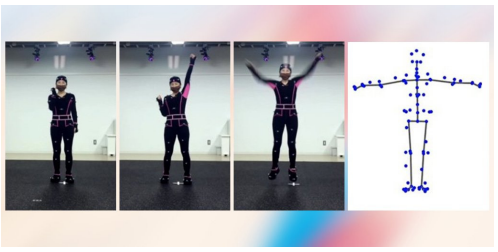


Contact to Professor KITAMURA Yoshifumi : yoshifumi.kitamura.b8@tohoku.ac.jp

Interdisciplinary ICT Research Center for Cyber and Real Space

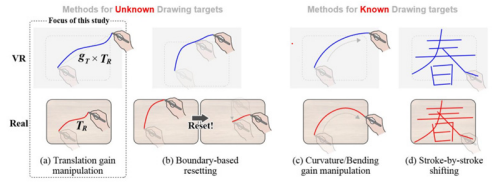
Enrich Telecommunication with Nonverbal Information

[Research Target and Activities]



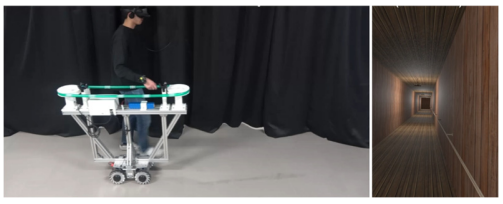
1. How Do Asians Express Emotions Through Body Movement?

   This new database aims to capture a wide range of emotional bodily expressions across various scenarios, with a focus on Japanese people born and raised in Japan [1].



2. VR technology that allows you to draw large letters on a virtual canvas of infinite size using a drawing on a small desk

   We propose Redirected Drawing, a novel methodology that applies visual manipulation to the user's drawing movement in VR to expand the perceived surface size required for the drawing experience [2].



3. Endless handrail with haptic feedback from grounded objects in Cyber/Virtual Space

   We propose LoopBot, a novel technique to provide endless handrail with haptic feedback from grounded objects using only a single user-following robot [3].

4. Large-scale Encountered-type Haptics in Cyber/Virtual Space

   We propose InflatableBots, shape-changing inflatable robots for large-scale encountered-type haptics in cyber/virtual space [4].

[Papers]

[1] Miao Cheng, Chia-huei Tseng, Ken Fujiwara, Shoi Higashiyama, Abby Weng, and Yoshifumi Kitamura. Toward an Asian-based bodily movement database for emotional communication, Journal: Behavior Research Methods, 57(1), 1-16. https://doi.org/10.3758/s13428-024-02558-2

[2] Kumpei Ogawa, Kazuyuki Fujita, Kazuki Takashima, Yoshifumi Kitamura: Redirected Drawing: Expanding the Perceived Canvas Size in VR, Proceedings of IEEE Virtual Reality and 3D User Interfaces, pp. 494-504, Saint-Malo, France, March 2025. https://doi.org/10.1109/vr59515.2025.00073

[3] Tetsushi Ikeda, Kazuyuki Fujita, Kumpei Ogawa, Kazuki Takashima, Yoshifumi Kitamura: LoopBot: Representing Continuous Haptics of Grounded Objects in Room-scale VR, ACM Symposium on User Interface Software and Technology (UIST), 2024. https://doi.org/10.1145/3654777.3676389

[4] Ryota Gomi, Ryo Suzuki, Kazuki Takashima, Kazuyuki Fujita, Yoshifumi Kitamura: InflatableBots: Inflatable Shape-Changing Mobile Robots for Large-Scale Encountered-Type Haptics in VR, Proceedings of the CHI Conference on Human Factors in Computing Systems, Article No. 423, 2024, https://doi.org/10.1145/3613904.3642069

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 2024＞

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. From these opportunities, we have five 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 the results of the projects are scheduled to be announced in 2025.

＜Member＞

Specially Appointed Professor Michihiro Shimada

Contact to Specially Appointed Professor SHIMADA michihiro : michihiro.shimada.b3@tohoku.ac.jp

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 (444 participants).
- ○ Web-based high-pressure gas safety seminars (155 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.

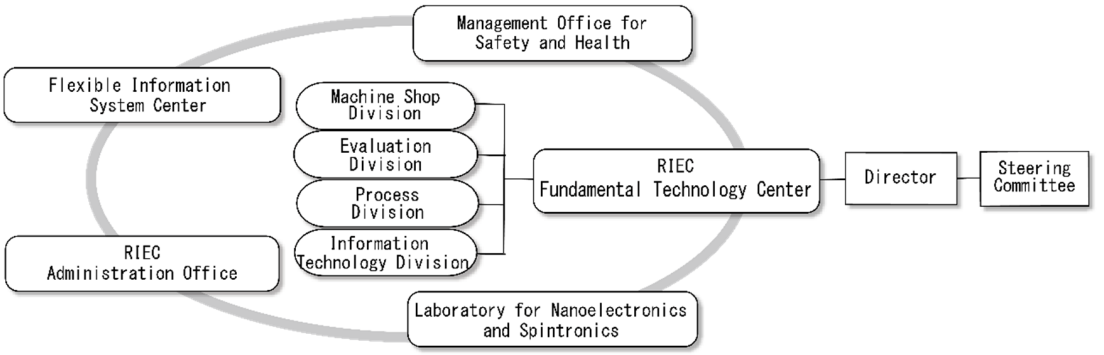
[Staff]

(1) Steering Committee
Professors: Go Hasegawa, Dr., Masafumi Shirai, Dr., Takuo Suganuma, Dr., Hiroshi Yasaka, Dr., Akio Ishiguro, 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 134 machining products. About 20% of the requests were from outside the institute.

2. Evaluation Division

25 laboratories and 5 external research institute and company utilized the evaluation and measurement apparatuses for shared usage (the utilization time was 2,191 hours). Technical assistance on the use of liquid helium was provided for 2 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, 374 Electron-beam lithography products, 32 photomasks and 13 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 2024, we continued discussion about our goal and research direction with several 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, to promote research on brainmorphic computing from a wide range of perspectives, including brain science, spintronics devices, analog and digital integrated circuits, cultured neural circuits, and nonlinear complex dynamics, we organized and presented our research in the Nonlinear Workshop. In addition, Horio, who is the PI of this group, gave a plenary lecture concerning the research in this group at the 2024 International Symposium on Nonlinear Theory and Its Applications. Furthermore, discussions within this group contributed significantly to some members obtaining Grants-in-Aid for Scientific Research (S).

[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 FY2024, as the starting year, we organized several opinion exchange meetings and laboratory tours to discuss future directions of our collaborative research as well as to consider strategies toward obtaining large-scale fundings.

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 2024＞

- **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 8th International Symposium for the Core Research Clusters for Materials Science and Spintronics was held in November 2024. The following international meetings were also co-sponsored or supported by CSIS:
- 2024 Japan-Korea Spintronics Workshop “Recent Progress on Spintronics” (May 2024)
- 2024 Spintronics Workshop on LSI (June 2024)
- 3rd International Workshop of Spin/Quantum Materials and Devices (November 2024)

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

＜About the Center＞

Establishment：April 1, 2024
Based on research activities as an Advanced Institute of Yotta Informatics is granted by MEXT from 2018 to 2023.

Organization：Director: Nobuyuki Sakai (Professor, Graduate School of Arts & Letters/RIEC)
Number of members: 46 (RIEC, Graduate School of Engineering, Graduate School of Arts & Letters, Graduate School of Information Sciences, Graduate School of Economics and Management, Graduate School of Biomedical Engineering, Graduate School of Education, Graduate School of Life Sciences, Graduate School of Agricultural Science, of International Cultural Studies, Graduate School Institute of Development, Aging and Cancer, International Research Institute of Disaster Science, Cyberscience Center, The Center for Academic Resources and Archives, Unprecedented-scale Data Analytics 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 2024＞

1. We employed four young informatics researchers (1 Associate Professor and 3 Assistant Professor) who have deep knowledges on human and social sciences.
2. We supported 17 multi-discipline projects, which integrate human or social sciences with informatics, and expected to lead the new information science.
3. We organized an international Kick-Off Symposium, in which 110 researchers participated from many countries. We also organized AI So-Go-Chi Symposium, where achievements of the 17 projects were discussed. We co-organized a RIEC international symposium “Tohoku U - NTU Symposium: When AI Meets Human Science," International Workshop on Emerging ICT, and HIP Research meeting of IEICE.

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: 80 (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 2024＞

CIES has managed the “CIES consortium” which consists of industry–academic collaborations, major national projects (MEXT X-nics, NEDO Post 5G, NEDO AIC, JSPS Core-to-Core, JAXA TansaX, MEXT Power Electronics, CAO SIP 3rd) and regional collaboration projects. We have promoted the development of core technologies related integrated electronics from material, equipment, devices and system 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. In FY2024, we were also awarded the CEATEC AWARD 2024 for the results of our “NEDO Energy Efficient AI Semiconductor and System Project" and the NE Power Electronics Award 2024 Grand Prize for our development of an ultra-compact double-sided cooled power module. 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 recent years, various semiconductor businesses based on semiconductor strategies have been developed in Japan and other countries, requiring advances in everything from R&D to human resource development. In November 2024, our university was certified as an International Research Excellence, and one of its goals will

be "research that brings change to the world (social impact)". Amid these domestic and international trends, we recognize that the responsibilities of the center, which operates in the semiconductor field, have increased significantly. In response to the demands of this social situation, the center has also begun to work on developing semiconductor human resources in addition to R&D activities. Specifically, we are working on developing highly skilled human resources in collaboration with 14 universities in Japan as part of the MEXT X-NICS Project "Innovative Spintronics X Semiconductor Research Hub". In addition, under the U.S.-Japan University Partnership (UPWARDS) for the Future concluded at the G7 Hiroshima Summit, this center is also working on innovative semiconductor R&D, manufacturing, supply chain, and human resource development through collaboration between industry and Japanese and U.S. universities.

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 succeeded in developing a low power consumption MRAM technology that has data retention for more than 10 years and rewrite tolerance that reaches 1 trillion times with the integrated technology of the single digit nanometer generation. We have demonstrated data retention at 260°C and over 10 million rewrites during manufacturing of cutting-edge microcontrollers using a new 6-layer interface perpendicular ferromagnetic magnetic tunnel junction device. In January 2024, the "Photonics-Electronics Convergence Interface Memory Module Technology" jointly proposed by Kioxia Corp. and NTT Corp. was selected for the NEDO "Project for Research and Development of Enhanced Infrastructures for Post 5G Information and Communications Systems" and we will participate as a subcontractor. This is a new large-scale national project that contributes to the IOWN concept promoted by NTT. We will be responsible for the development of high-bandwidth buffer memory in the technological development of photonic fabric attached memory modules (PFAM), which realizes memory that can be accessed by high-bandwidth light from multiple computing resources via optical interconnects. In addition, in October 2024, we will participate in a TDK project to promote the integration development of neuromorphic devices that can reduce AI power consumption by 1/100 using spintronics technology. As the project transitions from the element technology development stage to the development stage for practical application, we will contribute to this project by utilizing the academic knowledge and manufacturing technologies, such as the 300mm prototype line and evaluation equipment. 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, and have presented each of these at international conferences and received high praise. Furthermore, we have decided to establish the "Fuji Electric x Tohoku Univ. Advanced Technology Co-Creation Research Center" on November 1, 2024, in order to further strengthen our collaboration with our joint research partner Fuji Electric Co., Ltd. in the power electronics field and to identify development themes related to power electronics and green transformation (GX) that should be addressed in response to social issues after 2030. Utilizing the three core technologies, we aim to develop system 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 seventh year, and it has been put into practical use based on the technology and know-how of this center. In addition to Miyagi Prefecture, the Miyagi Advanced Electronics and Machinery Industry Association, the Miyagi Automotive Industry Promotion Council, Iwate Prefecture, Iwate Semiconductor and Electronics Industries Promotion Conference, local and local companies in Yamagata Prefecture were added, and regional cooperation was expanded with cooperation of the METI Tohoku. In addition, Director Tetsuo Endoh has been appointed as an advisor to the Tohoku Semiconductor Electronics Design Consortium (T-Seeds), which was launched in 2024, and we are working to strengthen the foundations of semiconductor and other related industries in Tohoku region and by extension in Japan, in cooperation with related organizations such as industry, universities, technical colleges, and government.

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 2024＞

In FY2024, 16 students completed the 5-year integrated education curriculum of the AIE-WISE program for AI Electronics. The program received high evaluations from the post-evaluation hearing at JSPS, the on-site visits by the program officer (PO) and the on-site visits by the external evaluation committee. The Project Based Learning (PBL) courses, which are unique to the AIE-WISE program, were delivered in a face-to-face format in FY2024. 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, six 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. All students in the program presented their research in English at the international symposium. We recruited and selected students for the seventh year, and 30 new students (13 new M1 students, 12 new M2 students, and 5 new D1 students) were selected.

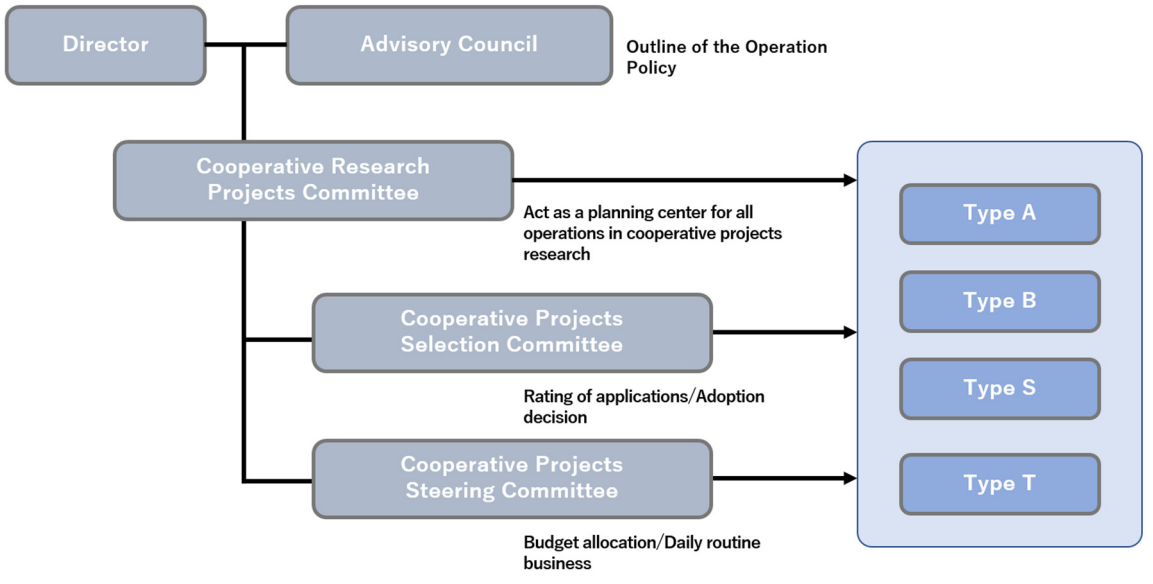
4. Nation-wide Cooperative Research Projects

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 Nation-wide 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 Nation-wide 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.



Nation-wide Cooperative Research Projects List 2024

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R04/A01	Coplanar waveguide size and magnetization angle dependence of magnetization dynamics in CoFeB-MgO magnetic tunnel junction structure measured by spin rectification ferromagnetic resonance	**Eli Christopher Inocencio Enobio**	**FUKAMI Shunsuke**
R04/A04	Study on Silicidation Reaction of Metal Nanodots with SiH4	**MAKIHARA Katsunori**	**SATO Shigeo**
R04/A05	Study of magnetic, dielectric and optical properties of nanomaterials for Terahertz applications	**AMINE El Moutaouakil**	**OTSUJI Taiichi**
R04/A08	High Frequency Response of Submicron-Sized Magnetic Materials with Asymmetric Magnetic Vortex Structure	**KODA Tetsunori**	**ISHIYAMA Kazushi**
R04/A09	Development of efficient magnetization-switching devices using transition metal compounds	**SHINJI Isogami**	**SHIRAI Masafumi**
R04/A11	Development of Diamond High-Frequency High-Power Devices and Circuits for Post-5G Base Stations	**KANEKO Junichi H**	**SUEMATSU Noriharu**
R04/A12	Manipulation of sense of self using multisensory information	**TANAKA Akihiro**	**SAKAMOTO Shuichi**
R04/A13	Exploring and designing interactions for VR headsets using smartphone interfaces	**BOUSTILA Sabah**	**KAZUYUKI Fujita**
R04/A19	Study of Superconducting Nanowire for Single Photon Detection	**MIMA Satoru**	**SATO Shigeo**
R04/A21	Wireless Propagation Channel for Body Area	**AKIMOTO Kohei**	**SUEMATSU Noriharu**
R04/A22	An Exploratory Study to Build an Environment for Collaborative HyFlex Classes" Utilizing XR Technology"	**HAYASHI Masako**	**KITAMURA Yoshifumi**

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**	**OTSUJI Taiichi**
R05/A08	Investigation of physical structure model of high-k/Ge interface affected by process temperatures	**OTANI Yohei**	**SATO Shigeo**
R05/A09	Study on plasmonic nanodevices integrated with two-dimensional materials	**UCHINO Takashi**	**OTSUJI Taiichi**
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**	**OTSUJI Taiichi**
R05/A14	Collaborative evaluation of non-verbal communication solutions	**Benjamin WATSON**	**CHENG Miao**
R05/A16	Research on dynamic VR/AR workspaces for inducing physical movements	**TAKAHARA Ryo**	**KAZUYUKI Fujita**
R05/A17	Auditory influences on saccadic suppression	**Hiu Mei CHOW**	**TSENG Chia-huei**
R05/A18	Constructive analysis of brain computing based on multicellular networks	**TANII Takashi**	**YAMAMOTO Hideaki**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R05/A19	Expansion of nonlinear complex systems theory to spatiotemporal systems and its applications	**HORIO Yoshihiko**	**HORIO Yoshihiko**
R05/A20	Characterization of Microstructure and Properties of High Performance Soft Magnetic Iron Alloys	**SUZUKI Shigeru**	**ISHIYAMA Kazushi**
R05/A21	New development of multicellular neurobiocomputing	**KAMIYA Haruyuki**	**YAMAMOTO Hideaki**
R05/A22	Motion Unit: A data-driven study on bodily emotion expressions	**FUJIWARA Ken**	**CHENG Miao**
R05/A24	Research on Autopoietic Service Platform Supporting Smart Society	**KITAGATA Gen**	**HASEGAWA Go**
R05/A27	Research on online text analysis using machine learning	**ZABIR Salahuddin Muhammad Salim**	**HASEGAWA Go**
R05/A28	Deep learning based object detection for ultra high resolution image sensing	**Matsumura Tetsuya**	**OTSUJI Taiichi**
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/A32	Enhancing Non-Verbal Communication through Facial Expression and Gestures using Generative AI	**PUNPONGSANON Parinya**	**KITAMURA Yoshifumi**
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**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
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**
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/A09	Research on seamless optical and wireless access networks between underwater and land using broadband optical integrated circuits	**YOSHIMOTO Naoto**	**OTSUJI Taiichi**
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**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
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**
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/A21	Motion tracking study on nonverbal communication: a case of emotion and body synchrony	**KITA sotaro**	**CHENG Miao**
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**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
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**
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/A34	Study of disaster prevention and reduction system for harmony between people and the environment	**TAKAHASHI Hideyuki**	**YOKOTA Nobuhide**
R06/A35	Study on the use of ICT technology to improve the efficiency of work to search for missing persons and evacuation guidance during disasters	**SUGIYASU Kazuya**	**YOKOTA Nobuhide**
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**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R06/A38	Investigation of the characteristics of audiovisual attention	**YAMAMOTO Kosuke**	**SAITO Godai**
R04/B03	Nanomaterial production by using novel gas-phase process and its application to high-performance devices	**UCIDA Giichiro**	**SATO Shigeo**
R04/B04	Control and exploartion of functions of quantum materials towards device applications	**MATSUNO Jobu**	**FUKAMI Shunsuke**
R04/B06	Designing the Next Normal of Academic Conferences	**MURAYAMA Hiromi**	**KITAMURA Yoshifumi**
R04/B07	Theory of object recognition in vision and audition	**KURIKI Ichiro**	**SAKAMOTO Shuichi**
R04/B08	Workgroup on fundamental technologies and issues of surface unmanned vehicles for sustainable society	**SUEDA Koh**	**KITAMURA Yoshifumi**
R04/B09	Studies on Generative Technology for Enriched Multimedia	**SONODA Kotaro**	**SAKAMOTO Shuichi**
R04/B10	Application study on microwave and laser SAR	**KOGI Yuichiro**	**YASAKA Hiroshi**
R04/B11	An Inter-personal Dimension of MA: Behavior, Physiology, and Engineering	**TSENG Chia-huei**	**TSENG Chia-huei**
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**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R05/B08	Study of methods for guiding a flock of crows	**TSUKAHARA Naoki**	**KITAMURA Yoshifumi**
R05/B11	Development and control of artificial cell membrane systems for measuring membrane protein functions based on semiconductor microfabrication technology and nanomaterial functions	**TERO Ryugo**	**HIRANO Ayumi**
R05/B13	Theoretical study of memory and learning in neural networks	**IKEGUCHI Tohru**	**HORIO Yoshihiko**
R05/B15	Research on fundamental technologies related to human and social sensing and intervention	**ARAKAWA Yutaka**	**OTSUJI Taiichi**
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**	**HORIO Yoshihiko**
R06/B03	Quantum Circuits Accelerator based on Stochastic Computing	**Lukac Martin**	**ONIZAWA Naoya**
R06/B04	Research on mode on light	**HAMAMOTO Kiichi**	**YOSHIDA Masato**
R06/B05	User Experience in Spatial Computing: Developing New Models of Fatigue for Interaction Design	**Tag Benjamin**	**KITAMURA Yoshifumi**
R06/B06	Conduct meetings on quality estimation and stabilization methods for satellite constellations	**KASHIWAZAKI Hiroki**	**HASEGAWA Go**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
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**	**HORIO Yoshihiko**
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**	**HORIO Yoshihiko**
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**	**HORIO Yoshihiko**
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**
R06/B17	High-dimensional neural-network information processing based on geometric algebra	**HIROSE Akira**	**SATO Shigeo**
R06/B18	An emulation environment for a nonvolatile FPGA	**DAISUKE Suzuki**	**HANYU Takahiro**

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**
R05/S01	Establishment for innovative coherent wave technology and its applications	**AOKI Toru**	**YASAKA Hiroshi**
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**
R04/T01	**Electromagnetic-Wave Transmission Technologies Workshop** Electromagnetic- and light-wave transmission technologies toward Society 5.0	**NISHIYAMA Hiroki**	**KASAI Keisuke**
R04/T02	**Technical committee for acoustic engineering** Research presentation on basic and application of acoustics, speech, hearing and multimodal systems	**SAKAMOTO Shuichi**	**SAKAMOTO Shuichi**
R04/T03	**Tohoku Plasma Forum** Fundamentals and applications of non-equilibrium plasma phenomena	**KANEKO Toshiro**	**HIRANO Ayumi**
R04/T04	**Special Interest Group on Computer Science** Foundation and Application of Information Science around Theoretical Computer Science	**SUMII Eijiro**	**NAKANO Keisuke**
R04/T05	**Technical committee for system control** Research presentation on theory and applications of system control	**WATANABE Takashi**	**ISHIGURO Akio**

Grant Number	Title of Research	Principal Investigator	Research Collaborator of RIEC
R04/T06	**Research presentation on theory and applications of system control** Next generation biodevices based on bio-nanoelectronics	**HIRANO Ayumi**	**HIRANO Ayumi**
R04/T07	**Spinics Research Society** Development of Magnetic Materials and Their Magnetic Applications	**ENDO Yasushi**	**ISHIYAMA Kazushi**
R04/T08	**New Paradigm Computing Research Group** Research and development of new paradigm computing technologies for the next generation IoT society	**HOMMA Naofumi**	**HOMMA Naofumi**
R04/T09	**Technical committee for ultrasonic electronics** Research presentation on basics and applications of ultrasound	**YOSHIZAWA Shin**	**SAKAMOTO Shuichi**
R04/T10	**Brainware Research Project** Toward Life-like Intelligent Information Processing System	**ISHIGURO Akio**	**ISHIGURO Akio**
R04/T12	**Study Group on Nanoelectronics and Spintronics** Next-generation information and communication technology based on nanoelectronics and spintronics	**SATO Shigeo**	**FUKAMI Shunsuke**
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**

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 FY2024)

No	Title	Date
130	21st RIEC International Workshop on Spintronics	Feb. 25-28,2025
131	The 13th RIEC International Symposium on Brain Functions and Brain Computer	Feb. 25-28,2025
132	10th CIES Technology Forum	Mar. 17-18,2025
133	RIEC International Symposium on Enriching Telecommunication and Nonverbal Information	Mar. 21,2025

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, Santa Barbara (U.S.A.)
- 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)
- The University of York (U.K.)
- National Yang Ming Chiao Tung University (Taiwan)
- The Technische Universität Dresden (Germany)
- University of Waterloo (Canada)
- University of Ottawa (Canada)
- Berlin Institute of Technology (Germany)
- National Tsing Hua University (Taiwan)
- Harvard University (U.S.A.)
- 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)
- Polish Academy of Sciences (Poland)
- Institute of Physics, Polish Academy of Sciences (Poland)
- IHP-Innovations for High Performance Microelectronics (Germany)
- The Interdisciplinary Center on Nanoscience of Marseille, National Center of Scientific Research (France)
- Institute of Semiconductors, Chinese Academy of Sciences (China)
- WINLAB, 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 Tech (Ecole Notionale Superieure des Télécommunications) (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	Auditory Perception & Cognition
2	Bioinspiration & Biomimetics
3	e-Journal of Surface Science and Nanotechnology
4	Frontiers in Physics
5	Frontiers in Psychology
6	Frontiers in Robotics and AI
7	IEICE Electronics Express
8	IEICE Transactions on Electronics
9	IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences
10	Journal of Cryptographic Engineering
11	Journal of Magnetism and Magnetic Materials
12	Journal of Physics D: Applied Physics
13	Magnetorchemistry
14	Nonlinear Theory and Its Applications, IEICE
15	Science and Technology of Applied Materials
16	Scientific Reports
17	Spin

Recent international conferences programmed by a staff in RIEC

1	14th International Workshop on Nanostructures & Nanoelectronics, RIEC, Sendai, Japan, Mar. 5-6, 2024
2	2023 IEEE 12th Global Conference on Consumer Electronics
3	EU-Japan Graphene Flagship Workshop 2023
4	Global Symposium on Millimeter-Waves & Terahertz (GSMM)
5	IEEE International Symposium on Radio-Frequency Integration Technology (RFIT)
6	INTERMAG2023
7	SPIE Optics+Photoics 2023
8	SPIE Photonics West 2023
9	The 10th International Symposium on Terahertz-Related Devices and Technology (TeraTech 2023)
10	The 11th International Symposium on Adaptive Motion of Animals and Machines
11	The 14th International Conference on “Recent Progress in Graphene and 2D materials Research (RPGR 2023)”
12	The 48th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz 2023)
13	TMRC 2023

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" is published.

With the 75th anniversary of the establishment of RIEC, RIEC News introduces 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 introduces special topics such as large-scale projects and Specially-Promoted Research, etc. RIEC News also includes current 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 is published by the following link.

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

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

8. Staff, Budget

1. Faculty & Staff

as of May 1, 2024

Professors	19
Associate Professors	19
Assistant Professors	11
Specially Appointed Professors	3
Specially Appointed Associate Professors	0
Specially Appointed Assistant Professors	5
Specially Appointed Research Fellows	6
Research Fellows	7
Administrative Staff（Including Limited Regular Employees）	28
Technical Staff（Including Limited Regular Employees）	14
Total	112

2. Researchers (FY2024)

Foreign Researchers	Visiting Professors	3
	Visiting Associate Professors	0
Cooperative Researchers of Private Company etc		7
JSPS Research Fellowship for Young Scientists		9
JSPS Postdoctral Fellowship for Overseas Researchers		2
Invitation Fellowship for Research in Japan		1
Contract Researchers		1
Contract Trainees		1
Total		24

3. Students

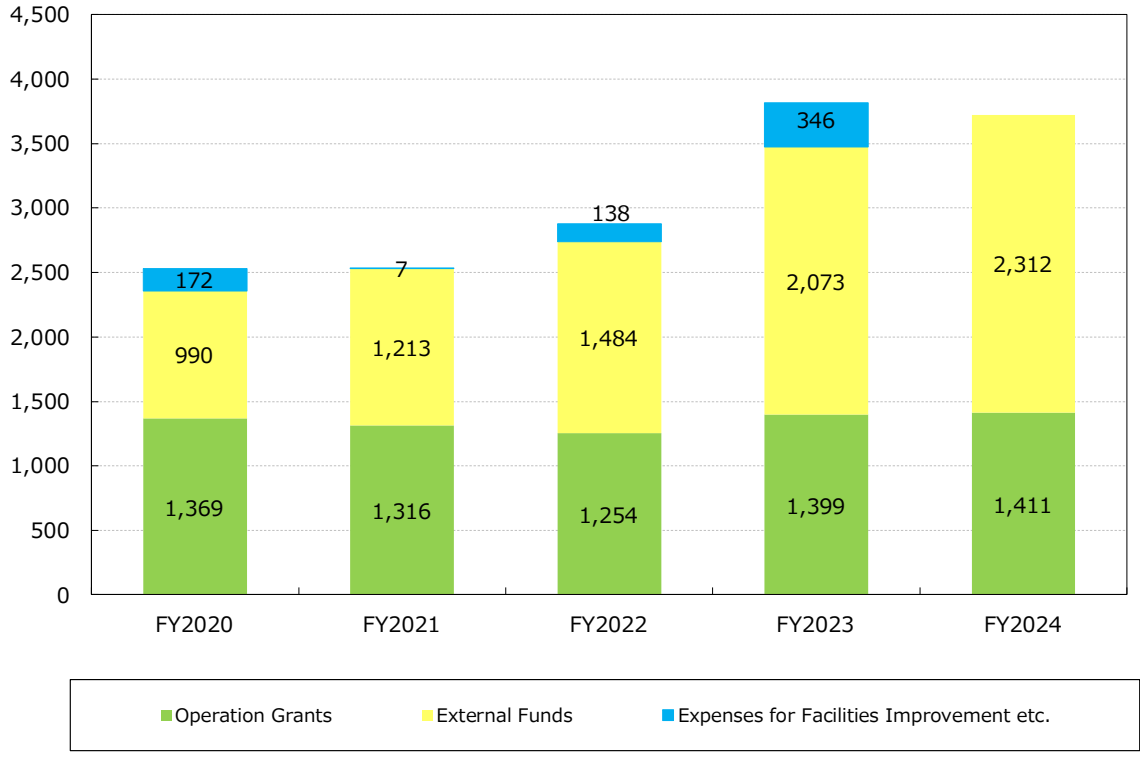
as of May 1, 2024

	School of Engineering	Graduate School of Information Science	Graduate School of Biomedical Engineering	RIEC	Total
Undergraduate Students	54 (2)				54 (2)
Master Course Students	83 (2)	40 (8)	4		127 (10)
Doctor Course Students	22 (7)	8 (4)	4		34 (11)
Institute Reserch Students				5 (3)	5 (3)
Total	159 (11)	48 (12)	8	5 (3)	220 (26)

4. Budget

Budget Shift

million yen



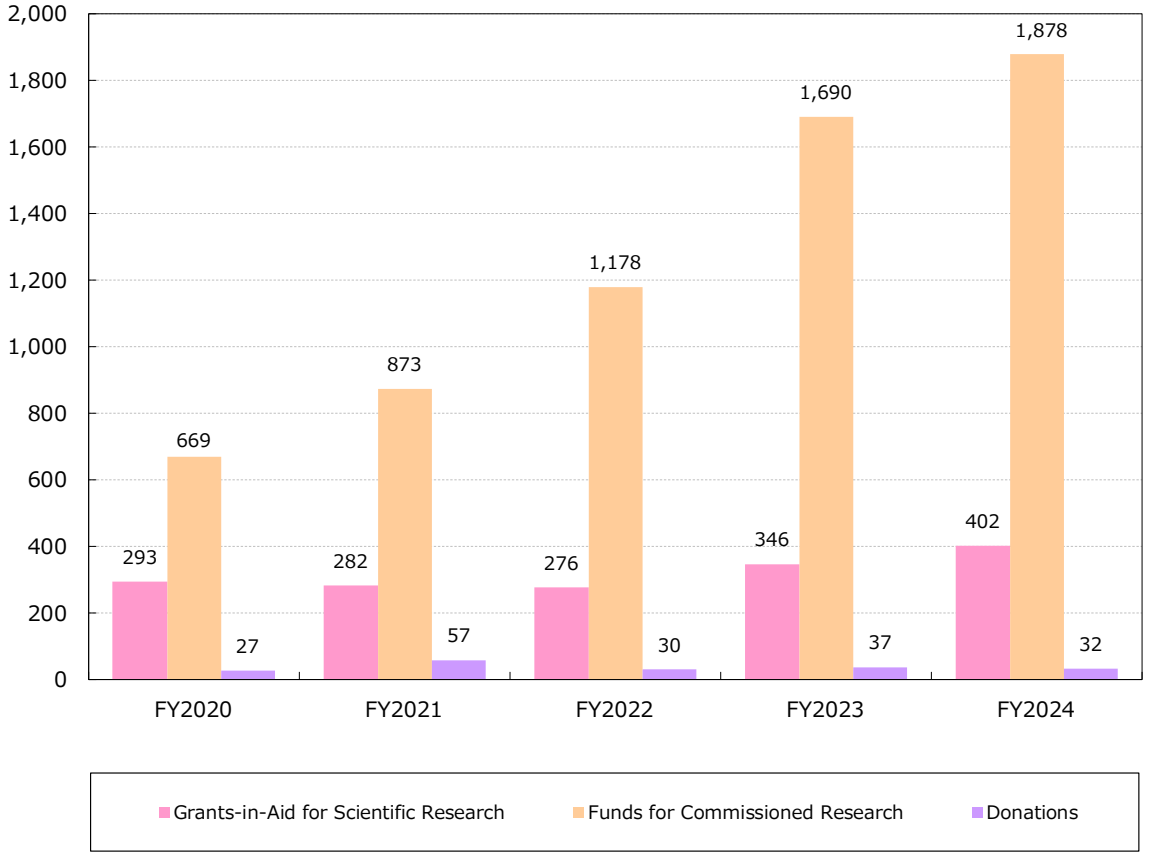
■ Budget Summary

thousand yen

Categories		FY2020	FY2021	FY2022	FY2023	FY2024
Operation Grants	Personnel Expenses	801,695	744,591	699,851	771,183	778,868
	Non-Personnel Expenses	567,249	571,737	553,851	628,159	632,286
Operation Grants Total		1,368,944	1,316,328	1,253,702	1,399,342	1,411,154
External Funds	Grants-in-Aid for Scientific Research	293,404	282,400	276,146	346,119	402,110
	Funds for Commissioned Research	669,454	873,456	1,178,325	1,689,946	1,878,010
	Donations	27,200	57,422	29,604	36,742	32,011
	Indirect Expenses	172,874	234,487	315,346	455,413	518,716
External Funds Total		990,058	1,213,278	1,484,075	2,072,807	2,312,131
Expenses for Reconstruction		172,477	6,732	20,472	32,956	0
Expenses for Relocation		0	0	0	0	0
Expenses for Facilities Improvement		0	0	117,997	313,203	0
Expenses for Facilities Improvement etc. Total		172,477	6,732	138,469	346,159	0
Total		2,531,479	2,536,338	2,876,246	3,818,308	3,723,285

External Funds

million yen



■ External Funds

thousand yen

Categories	FY2020	FY2021	FY2022	FY2023	FY2024
Grants-in-Aid for Scientific Research	293,404	282,400	276,146	346,119	402,110
Funds for Commissioned Research	669,454	873,456	1,178,325	1,689,946	1,878,010
Donations	27,200	57,422	29,604	36,742	32,011
Total	990,058	1,213,278	1,484,075	2,072,807	2,312,131

Annual Report 2024

Research Institute of Electrical Communication
Tohoku University

2-1-1Katahira, Aobaku, Sendai 980-8577, Japan
Tel. +81-(0)22-217-5422　Fax. +81-(0)22-217-5426
https://www.riec.tohoku.ac.jp/en/

Research Institute of Electrical Communication
Tohoku University

2-1-1 Katahira,Aobaku,Sendai 980-8577, Japan
Tel. +81-(0)22-217-5420 Fax.+81-(0)22-217-5426
https://www.riec.tohoku.ac.jp/en/