RIEC Newsletter No.6

RIEC News

RIEC Newsletter
Research Institute of Electrical Communication
Tohoku University

TOHOKU UNIVERSITY

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Research Institute of Electrical Communication
No.6
2019.3
Tohoku University

SHIOGAMA-JINJA Shrine (Photo by Miyagi Prefecture Tourism Division)

Special ISSUE

Director's Message

Director Prof. **Satoshi Shioiri**

I am honored to have responsibility to serve as the director of Research Institute of Electrical Communications, RIEC. The mission of RIEC is to realize a new paradigm of communications that enriches people' s lives. Communication has a variety of importance in the human society, and information communication technology (ICT) has been changing the way we deal with information drastically. It has been overriding our biological limitation and expanding the world of communication from among people to among things as well as among people and things. RIEC is determined to work for future society with further advanced ICT, contributing to the welfare of human beings.

Since its foundation in 1935, RIEC has made a series of pioneering achievements in laying the foundations of modern information and communication technology, including magnetic recording systems, semiconductor devices and optical communication technologies, and has played a world-leading role. We cover research fields of material, device, communication system, networks, human and software engineering and sciences related to ICT, to promote the fusion of research fields between hardware and software sciences, and also to promote the integration of arts and sciences.

RIEC is organized into four research divisions, two laboratories, and one center. The three research facilities have different scope in terms of research period: divisions, laboratories and the center focus on long-, medium-, and short-term projects, respectively. The Information Devices Division carries out research into materials and devices for communication technology. The Broadband Engineering Division specifically examines the development of new technologies for the transmission and storage of vast quantities of data. The Human Information Systems Division conducts research into intelligent information processing. The Systems and Software Division is developing advanced system software for the new information society.

There are two research laboratories. The Laboratory for Nanoelectronics and Spintronics is carrying out fundamental research into high-speed semiconductor devices and advanced nano-spin science and the Laboratory for Brainware Systems is working towards its long-term goal of the seamless fusion of real and virtual worlds at the human-computer interface. The Research Center for 21st Century Information Technology promote short-term collaboration with the industrial or academic partners in the field developed in the research divisions.

We have been certified by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) as a Joint Usage/Research Center for collaborative research in information and communications technology and are engaging in joint research projects with outside researchers. We are soliciting a full range of joint research projects including those centered on collaboration with industry, on international development, and on younger researchers. This year we are conducting more than 140 joint research projects with more than 1,300 participants.

We have been promoting the government-funded Brainware LSI Project since fiscal 2014, which aims to create LSIs based on new concepts that are capable of human-like judgment. This program is creating advanced information processing LSIs, such as those of artificial intelligence, which can be applied to real-world situations. Within the university, we are also expanding R&D projects centered around RIEC. In March 2010, Tohoku University established the Center for Spintronics Integrated Systems, where RIEC members and others are working on a collaborative project between industry, academia and government to develop low-power logic integrated circuits using spintronics technology with the support of the government' s ImPACT program. In October 2011, in response to the Great East Japan Earthquake, Tohoku University resolved to set up the Research Organization of Electrical Communication under the leadership of RIEC. As one of the eight major projects underway at Tohoku University' s Institute for Disaster Reconstruction and Regeneration Research, research and development for the creation of disaster-tolerant ICT is being carried out through collaboration between industry, academia, and government. RIEC also played a key role in establishing the Center for Innovative Integrated Electronic Systems in 2012 to develop and realize advanced integrated systems on a chip. Furthermore, in 2016, two additional Centers were established. One is the Yotta Informatics Research Center, which is supported by the government from 2018, based on a project for handling the "quality" of information to meet challenges "beyond big data" involving researchers from both arts and sciences fields. The other is the Center for Spintronics Research Network, which was funded by the government to establish a worldwide network for spintronics research. Tohoku University is one of the four key universities (together with the University of Tokyo, Osaka University, and Keio University) to operate this network.

RIEC will respond to present-day needs, open up new worlds of communication for the future, work together with industry to create core technologies leading to the development of new industries, and, through these efforts, will offer a world-class education environment. In addition to providing innovative solutions to problems through the application of ICT, we will continue to work hard to open up a new era of academically rooted innovation befitting a university, to contributing to the welfare of human beings by realizing a new paradigm of communications that enriches people' s lives.

TOPICS 1

International Symposium on Photonics and Optical Communications (ISPOC 2017)

The International Symposium on Photonics and Optical Communications (ISPOC 2017) was held at RIEC, Tohoku University, on October 25-26, 2017. The purpose of this symposium was to provide an opportunity for researchers working in areas in photonics to communicate and exchange ideas. The importance of photonics has been increasing rapidly in many fields from advanced technologies such as ultrahigh-speed large-capacity communication, ultrashort pulse sources, optical devices and highly precise optical measurement, to biological and medical applications. The symposium featured a plenary talk by Prof. Erich P. Ippen of MIT and six invited talks by eminent researchers, who described their latest work on silicon photonics, optical material physics, quantum photonics, THz engineering, and optical communications. In addition, as part of a series of "Tohoku University Optical Science and Technology Forum," which has been organized by researchers in RIEC and other departments over the past ten years, our research activities on photonics were introduced by eight professors including optical communication, measurement, light sources, devices, and material physics. A poster session was also organized that focused on cutting edge photonics research at Tohoku University, where 25 young researchers presented their work and the participants enjoyed stimulating discussions. The symposium concluded with a special talk given by Prof. Masataka Nakazawa to commemorate his retirement. He traced back his pioneering works on erbium-doped optical amplifiers and their enormous contributions to advanced optical communications as well as their future prospects, which left a profound impression on the audience. In parallel to the technical sessions, there were exhibitions to which 11 companies involved in optical communication, devices and test equipment contributed. These exhibitions offered a valuable opportunity for participants to gain up-to-date information on the latest commercial products. The total number of participants was 132, and the symposium concluded with a great success.

TOPICS 2

Eyes in the back of the head

Spatial representations of surroundings, including those outside the visual field, are crucial for guiding movement in the three-dimensional world. The visual system appears to provide sufficient information for movement despite our limited visual field to the frontal region. However, this theory had not been scientifically tested until now.

We used a visual search experiment to demonstrate that the human visual system indeed has the ability to perceive things beyond the limits of the visual field. The team designed a 6-panel-display which covered a 360 degree area surrounding the viewer. On each panel display, six letters appeared at the same time.

The viewer was asked to find a particular letter and the time it took to find the target was recorded. After repeated exposure to the same spatial layouts surrounding the viewer, locating the target object became faster even if the viewer had no explicit knowledge of the repetition. This happened even when the target letter was located in the rear, which shows that visual processing is not limited to the visual field, but extends to a wider field around the viewer.

The results indicate that representations of surroundings exist in the brain that can be used to "look back" without the need for turning, perhaps for smooth and efficient movement. In other words, our brain constructs a 360-degree world even though visually we are usually only aware of the area in front of us.

This is the first study that has scientifically sought to demonstrate this spatial ability. It is an important step for revealing the brain function which links perception and movement.

Experimental setup to investigate implicit learning of surroundings.

INSIDE the Laboratory

Human Information Systems Division

Real-world computing lab. (Ishiguro-Kano lab.)

Akio Ishiguro, Real world computing, Prof.
Takeshi Kano, Real world mathematical modeling, Associate Prof.
Akira Fukuhara, Real world computing, Assistant Prof.

URL: http://www.cmplx.riec.tohoku.ac.jp/

Laboratory members

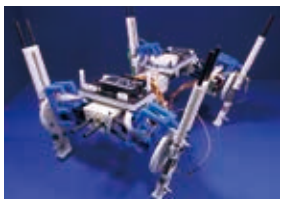
Animals exhibit adaptive and versatile locomotion under unpredictable environments by coordinating their large number of bodily degrees of freedom. In our laboratory, we aim to understand the underlying decentralized control mechanism on the basis of a synthetic approach, an approach to understand mechanisms through behavioral experiments, mathematical modeling, and robot experiments. We study various animals such as quadrupeds, insects, myriapods, brittle stars, and snakes. Here we briefly introduce our studies on quadrupeds and brittle stars.

1) Quadrupeds

Quadrupeds change their gait patterns from walk to trot to gallop as the locomotion speed increases to achieve energy efficient locomotion. Although these gait patterns likely generate via inter-limb coordination, the underlying mechanism had long been unclear. We proposed an extremely simple decentralized control mechanism for inter-limb coordination that exploits physical interaction, and demonstrated with a developed quadruped robot that the gait transition is achieved by using the proposed control mechanism.

2) Brittle stars

Conventional robots required a considerable amount of time (several tens of seconds) to adapt when they incur unexpected physical damage. To address this problem, we focused on a brittle star - a primitive echinoderm with five flexible arms. Brittle stars lack a sophisticated central nervous system, yet are able to immediately adapt to an arbitrary loss of their arms and still move by coordinating the remaining arms. Based on behavioral experiments, we proposed a simple decentralized control mechanism. This mechanism was implemented in a brittle star-like robot to demonstrate that it can adapt to unexpected physical damage within a few seconds, like its biological model.



Quadruped robot that exhibits gait transition

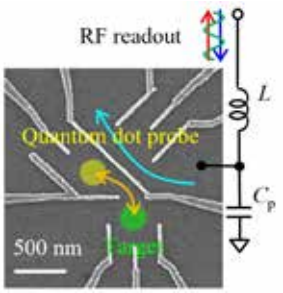
Brittle star-like robot that can adapt to physical damages

Information Devices Division

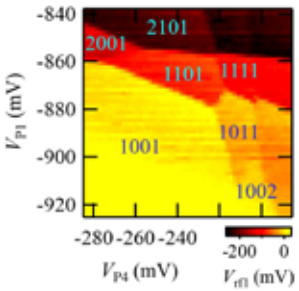
Quantum Devices Laboratory

Tomohiro Otsuka, Associate Professor

URL: http://en.qd.riec.tohoku.ac.jp/



Scanning electron micrograph of a nanostructure device



Charge state control in a nanostructure device

Quantum Devices Laboratory (Otsuka Group) started in February 2018. Our offices are in the RIEC main building and our labs are in the Laboratory for Nanoelectronics and Spintronics. We are now constructing our new lab by installing equipment and instruments.

We are studying interesting phenomena in solid-state nanostructures. In solid-state nanostructures, exotic phenomena like quantum effects occur. We can control the effects by preparing artificial nanostructures utilizing nanofabrication techniques. One example is a semiconductor quantum dot, which confines an electron in a small region. The size of the confinement is as small as the wavelength of an electron in a semiconductor and the size quantization occurs. We can tune the confinement by changing voltages applied on the device and control the artificial quantum levels. This quantum system especially utilizing the spin degree of freedom is nowadays considered as a candidate of a quantum bit for quantum information processing. We are exploring interesting properties of such nanostructures and developing new devices utilizing artificial nanostructures. We will contribute to new information processing and communication technologies through quantum and nanoelectronics.

We are measuring and controlling electronic properties of nanostructures utilizing some key experimental techniques. Nano-fabrication techniques enable us to prepare controllable artificial nanostructure devices. We can detect the dynamics of single-electron states in nanostructures by precise and high-speed electric measurements. We can access the fragile quantum states in ultra-low temperatures realized by cryogenic techniques.

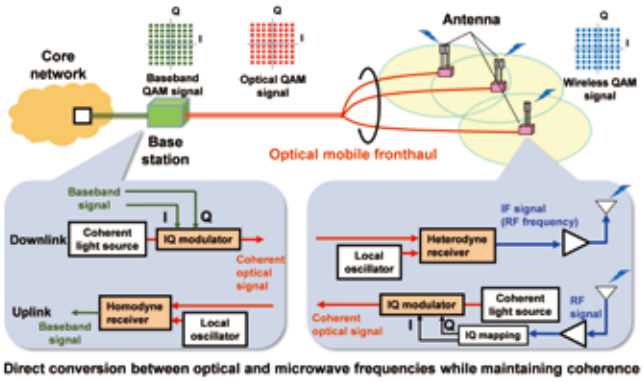
Please visit us if you have an interest in these topics and techniques.

Broadband Engineering Division

Ultrahigh-speed Optical Communication Laboratory

Toshihiko Hirooka, Professor
Keisuke Kasai, Assistant Professor
Hisao Kuroda, Research Fellow

URL: http://www.hikari.riec.tohoku.ac.jp/



Toward coherent integration of optical and wireless communications.

Our laboratory, which was founded by Prof. Masataka Nakazawa in 2001, has been actively engaged in research on fundamental technologies for ultrahigh-speed optical communication, including the generation and transmission of ultrashort optical pulses, ultrafast pulse lasers, digital coherent optical transmission, and highly precise fiber measurements. In April 2018, Toshihiko Hirooka was appointed as a professor, and the laboratory personnel currently consists of Keisuke Kasai (Assistant Professor), Hisao Kuroda (Research Fellow), one Ph.D. student, two master course students and one bachelor student.

Optical communication systems have evolved as a core technology of the ICT infrastructure and become widely used in society. This widespread deployment has been enabled by the progress made on light sources, transmission media, and signal processing, and by taking advantage of their high-speed and broadband operation. In the future, further innovation is expected that will realize flexible communication links capable of accommodating massive increases in the amount of information being handled at any given time, and transmitting it anywhere, and between many types of device.

In this laboratory, we aim at establishing ultrahigh-speed, large-capacity, highly secure and resilient optical communication technologies that can even be integrated with wireless communication by taking full advantage of the coherence of lightwaves. We also intend to develop functional optical systems capable of handling such transmissions with extremely high energy efficiency.

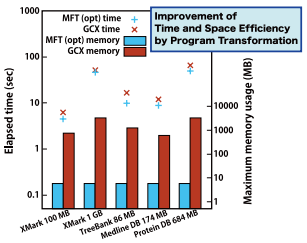
RIEC has a solid reputation as “the cradle of optical communication”. We would like to hand this reputation on to the next generation and develop a new horizon of optical communication technologies.

Systems & Software Division

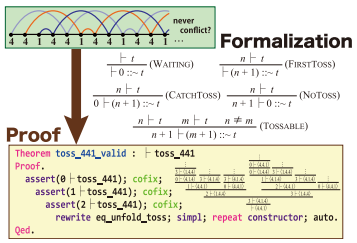
Computing Information Theory Laboratory

Keisuke Nakano, Professor
Kazuyuki Asada, Assistant Professor

URL: http://www.ipl.riec.tohoku.ac.jp/



Performance Improvement by Program Transformation



Formalization of Mathematical Juggling in Coq

Computing Information Theory Laboratory directed by Prof. Keisuke Nakano was inaugurated in April 2018. The research interests of our laboratory focus on the theory of programming and programming languages.

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.

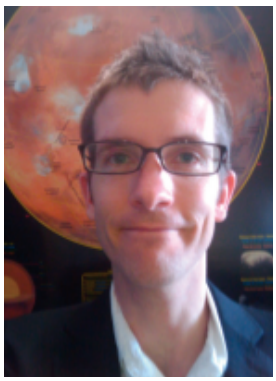
More specifically, our research topics include program transformation and verification. *Program transformation* is to automatically derive well-tuned and efficient programs from human-readable ones; *Program verification* is to statically (that is, without running) check if human-written but well-tuned 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.

The results and usefulness of theoretical researches on programming may be less visible than those of trendy and eye-catching researches in computer science. However, most electronic devices cannot be developed without programming in which program optimization and verification play a crucial role. The members of our laboratory are proud to be “unsung heroes”.

VOICES From International Researchers in RIEC

Mark Sadgrove

Associate Professor,
Broadband Engineering Division,
Quantum-Optical Information Technology



Mark Sadgrove earned his PhD in physics from the University of Auckland in 2006. In the same year he arrived in Japan to work as a post doctoral researcher at The University of Electro-communications (UEC). Before joining RIEC as an associate professor, he worked as an assistant professor at the Center for Photonic Innovations, UEC.

Soon after I joined RIEC, I went on a walk to see the Hasegawa river. Only 5 minutes walk from the institute, it is nonetheless an impressive natural setting. The high cliffs along with the rocky, sandy river banks, allowed me to imagine that I was far from the city. Above my head, hawks trilled as they floated on the midday thermals. If I had walked 15 minutes in the opposite direction, I would have arrived at the covered arcades of Sendai which are as bustling as many districts of Tokyo in the weekend.

These are the central attractions of living in Sendai and working at RIEC in Tohoku University' s Katahira campus. Minimally disturbed natural settings may be found within walking distance of the city center, despite Sendai being a city of 1 million people. The Hasegawa river which snakes around the town often provides an undeveloped boundary between these two worlds in a way that would be unthinkable in one of Japan' s larger urban centers.

RIEC itself, is a storied institution and devices developed at RIEC have become widely used in the real world. Another remarkable feature of RIEC is its interdisciplinary nature: robotics and software experts share the institute with biological engineers, nanoscientists, and quantum physicists.

Working at RIEC, then, allows inspiration from multiple sources: nature with its intriguing order and disorder, the urban bustle with its mixture of human pleasures and interactions, and of course the rich scientific heritage of the institute itself.

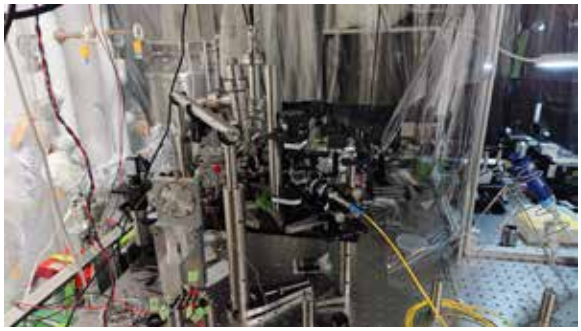


Fig. Magneto-optical trap for Rb atoms developed by Assoc. Prof. Sadgrove

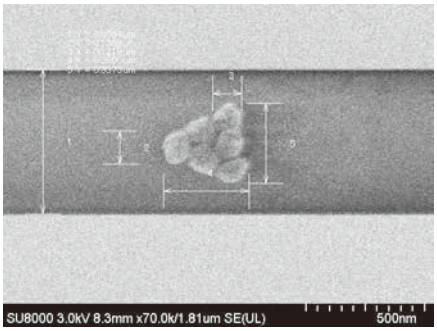


Fig. An array of nanoparticles on a nanofiber. Created by M. Sugawara Msc in the laboratory of Assoc. Prof. Sadgrove

Chia-huei Tseng

Associate Professor,
Human Information Systems Division,
Visual Cognition and Systems

Chia-huei Tseng received her PhD in Psychology from University of California, Irvine for PhD after her undergraduate training at National Taiwan University. She was a post-doc researcher at Rutgers University, New Jersey, USA before she returned to Asia. She was a faculty member at National Taiwan University, and the University of Hong Kong before joining RIEC.

The two-body problem is a constant challenge in my cross-cultural marriage. As a Taiwanese native married to a Japanese man, our ideal home is where we both can develop our professional careers with equal opportunity. Japan was on our wish list, but many had told us that without speaking the local language or knowing the system, it would be extremely difficult to start an academic career in Japan. Therefore, when I was given the chance to join RIEC as an associate professor, we were overjoyed with disbelief. I had met all the colleagues from my host lab led by Professor Shioiri at past conferences, and it was exciting to join a world-respected research group.

I joined RIEC in September, 2016, with very limited Japanese ability. In the past two years, I have surf on the waves of cultural shocks at work and life continuously, and my head is above water because of the guidance and supports from many colleagues and friends. My daily lab supervision of talented Tohoku students is a true privilege, which gives me a direct window on the future and challenges of Japan. My recent participation in Miyagi-Citizen University Open Lecture gave me a valuable co-work experience with administrative colleagues to reach out to the community. This position has provided the excellent research, teaching and service opportunities that a world-class university can offer. In return, my presence with diverse thinking/behavioral styles might also stimulate those around me to re-examine their world views and believes.

I have one caution for those who are considering applying to RIEC: Sendai/Miyagi is famous for its seafood, meats, vegetables, fruits, rice, water and sake!! You will need to be self-disciplined to keep fit.

Memorial Ceremony for Professor Jun-ichi Nishizawa.

Professor Jun-ichi Nishizawa, a former president of Tohoku University and a former director of our institute, passed away on October 21th and Memorial Ceremony was held on December 16th in 2018 at Westin Hotel Sendai.

President Ohno of Tohoku University offered a message of condolence, referring his words, "truth is in the lab, not on the desk". The message states Prof. Nishizawa's great contribution to the field of semiconductor such as invention of the PIN diode, static induction transistor, three elements of optical communication and so on. President Ohno also expressed his resolution that he would lead Tohoku University under the spirit of Research First, one of three spirits of Tohoku University, which Prof. Nishizawa embodied through his research carrier.

All the people who offered condolence messages, the governor of Miyagi prefecture, the mayor of Sendai city, colleague, friend and student expressed his incredible research achievements as well as his great personality. In some of the messages, Professor Nishizawa was addressed as Mr. semiconductor and Mr. Tohoku University. I felt that all the people there agreed that Professor Nishizawa really deserves such names.

After the ceremony, 800 people in total offered flowers and prayed for him.

Commendations & Awards

●Prof. Taiichi Otsuji
/ Fellow of the OSA (Optical Society of America) [22 Oct 2018]
for "pioneering contributions to terahertz emission and detection exploiting two-dimensional plasmonic and electronic systems with semiconductor nano- and hetero-structures."

●Prof. Yasuo Cho
/ Award for Best Review Paper, Japan Society of Applied Physics [6 Jul 2018]
"High resolution characterizations of fine structure of semiconductor device and material using scanning nonlinear dielectric microscopy."

●Dr. Daisuke Suzuki and Prof. Takahiro Hanyu
/ Best Poster Award in The 3rd ImPACT International Symposium on Spintronic Memory, Circuit and Storage [29 Jun 2018]
"Design of a Multi-Functional MTJ-Based FPGA for an Ultra-Low-Power Microcontroller Unit."

●Assoc. Prof. Shunsuke Fukami
/ AUMS Young Researches Award, Asian Union of Magnetic Societies (AUMS) [5 Jun 2018]
"Spin-orbit Torque Switching and its Applications - From High-Speed Memory to Artificial Neural Network -"

●Prof. Taiichi Otsuji
/ Fellow, Japan Society of Applied Physics [10 May 2018]
for "pioneering research on terahertz devices utilizing two-dimensional plasmon resonance phenomena."

●Assoc. Prof. Tomohiro Otsuka
/ The Young Scientists' Prize, The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology. [17 Apr 2018]
for "probing and Controlling Local Electronic States in Nanostructures."

●Prof. Yoshihiko Horio
/ Fellow(Engineering Sciences Society),the Institute of Electronics, Information and Communication Engineers (IEICE) [22 Mar 2018]
for "study on brain-inspired information processing and its hardware implementation."

●Assoc. Prof. Tomohiro Otsuka
/ Yazaki Research Encouraging Award, Yazaki Memorial Foundation for Science and Technology Research Grants [8 Mar 2018]
for "Dynamic measurement of local electronics states in nanostructures utilizing fast quantum dot probes."

●Mr. Takashi Maehata, Assoc. Prof. Suguru Kameda and Prof. Noriharu Suematsu
/ The 2017 Best Paper Award in Smart Radio, Technical Committee on Smart Radio, the Institute of Electronics, Information and Communication Engineers(IEICE) [2 Mar 2018]
"Distortion compensation method with asymmetric waveform consideration in concurrent dual-band 1-bit bandpass delta-sigma modulator."

International Symposia organized by the Institute

EVENT Calendar	Date	Venue
12th Global Symposium on Millimeter Waves 2019 (GSMM2019)	22 – 24 May. 2019	Sakura Hall, Katahira Campus
International Workshop on Emerging ICT	31 Oct. – 2 Nov. 2019	Aobayama Campus [TBD]
The Fourth Human-Computer Interaction Asian Symposium	Nov. 2019 [TBD]	RIEC
17th RIEC International Workshop on Spintronics	8 – 9 Jan. 2020	RIEC
The 8th RIEC International Symposium on Brain Functions and Brain Computer	20 – 21 Feb. 2020	RIEC
The 7th International Symposium on Brainware LSI	28 – 29 Feb. 2020	RIEC
The 11th International Workshop on Nanostructures and Nanoelectronics	4 – 5 Mar. 2020	RIEC
International Symposium on Yotta Informatics	TBD	RIEC

RIEC

Editor's Note

We are currently re-organizing our website. Please take a look at our website for latest information of RIEC. Feedback is welcome!

(H.O.)

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

For more information

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