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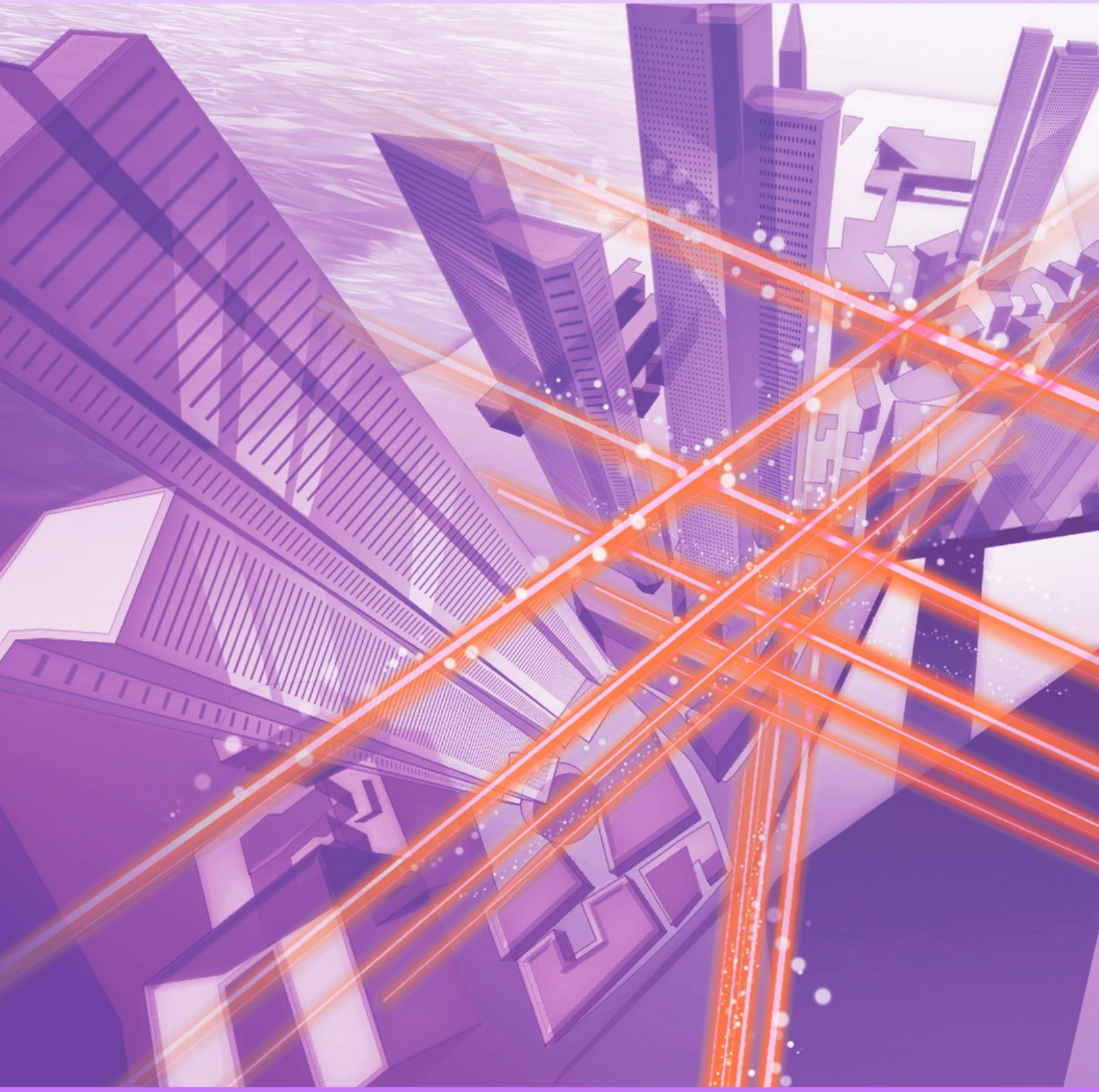

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Exploring New Fields and the World

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Overview

In April 2020, NTT formulated a technology roadmap for implementing the Innovative Optical and Wireless Network (IOWN). *Photonic disaggregated computing*, one of the key technologies that make up IOWN, is generating great interest as a new architecture that shifts from the conventional physical-server-oriented computing platform to a serverless computing platform based on photonic data planes. We asked Masaya Notomi, a senior distinguished scientist at the Nanophotonics Center of NTT Basic Research Laboratories conducting basic research on enabling photonic disaggregated computing, about his current research efforts and attitude as a researcher.

Keywords: nanophotonics, photonic crystals, all-optical switch

Announcement of research results that attract attention from around the world

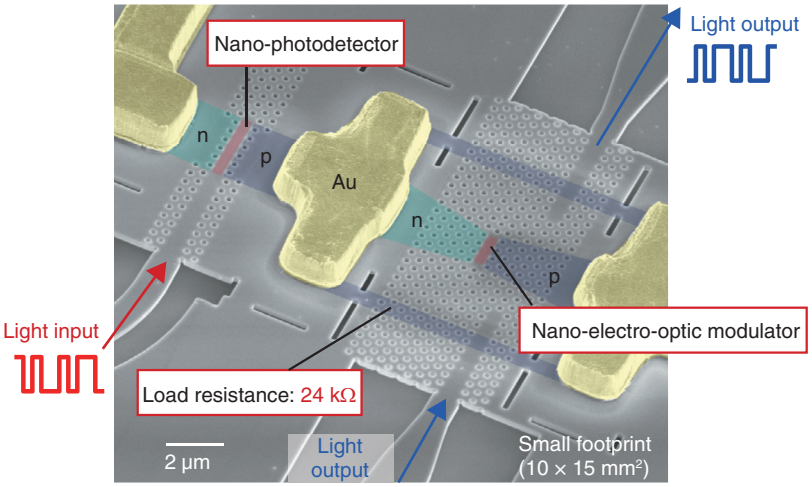
—Could you tell us about the research you are currently working on?

Currently, I am working on two themes. One is developing opto-electronic integrated processors using integrated nanophotonics[*1] by further advancing research on photonic crystal devices that operate with the world's lowest energy consumption, which we achieved about 10 years ago. By constructing a photonic network on a chip, we are trying to break through the limits of conventional integrated-circuit technology in terms of processing capacity, delay, and power consumption.

By fully using the nanophotonics technology we developed thus far, we have devised the following three devices: (i) a nano-photodetector that has the potential to convert optical signals to electrical signals with zero electric energy consumption; (ii) nano-electro-optic modulator that performs electro-optical conversion with only 6% the energy consumption of a previously reported modulator; and (iii) optical transistor that combines these devices [1] (**Fig. 1**).

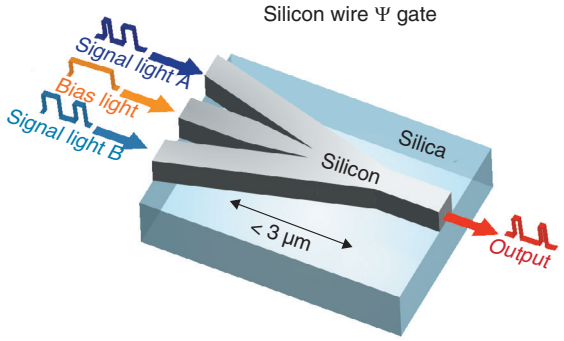
A processor is generally composed of a combination of many logic-operation circuits, each of which is composed of a combination of logic gates, and each gate is composed of a combination of transistors. After developing the optical transistor, we successfully demonstrated the world's first low-loss, high-speed operation of a small optical logic gate called "Ψ (psi) gate" that operates by optical interference only. We published a paper about this in March 2020 [2] (**Fig. 2**). With this technology, typical logic operations (AND, XNOR, NOR, etc.) can be carried out with ultralow delay in a wavelength-independent

*1 Nanophotonics: The movement of light and the interaction between objects and light on the nanometer scale. It is a new research field in optics and deals with controlling lightwaves and light-matter interactions with artificial nanometer-scale structures.



Fabricated by integrating a photodetector and electro-optic modulator with capacitance of 1 femtofarad or less.

Fig. 1. Structural diagram of optical transistor using ultralow-capacitance opto-electronic conversion technology.



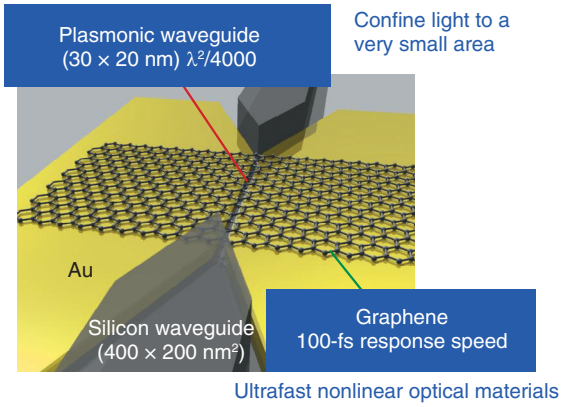
Various Boolean operations (such as AND and NOR) can be executed simultaneously using the same device.

Fig. 2. Optical logic gate operations using optical interference.

manner by using only a single Ψ gate. By this gate integrating with a high-speed optical modulator, it is possible to simultaneously carry out different operations to each wavelength channel (wavelength-division multiplexed parallel computation). Coordinating various devices, such as operation circuits, will make it possible to devise the first opto-electronic integrated processor with low latency and low power consumption that has specific functions.

The second theme, which is a more fundamental research, is on novel optical phenomena. Part of this research is being conducted jointly with a laboratory of the Tokyo Institute of Technology, at which I also hold a post. New nanoscale materials (nanomaterials), such as carbon nanotubes, have recently been discovered and have been shown to have various functions. By applying nanophotonics technology to these nanomaterials and generating interactions between nanomaterials and light, it has become possible to discover various new phenomena. For example, simply placing an InAs/InP (indium arsenide/indium phosphide) nanowire on a silicon photonic crystal[*2] will create an optical nano-resonator at that point. We have also succeeded in demonstrating laser

*2 Photonic crystal: A structure in which the refractive index is artificially modulated at a period similar to the wavelength of light in a substance. It can generate various novel properties and strongly confine light.



Interaction is enhanced using a miniaturized optical waveguide with a cross-section of 30 × 20 nm. A switch operates in less than one picosecond with the lowest energy consumption ever reported.

Fig. 3. All-optical switch with graphene-loaded plasmonic waveguide.

oscillation by using nanowires with a size less than the wavelength of the laser. Moreover, by combining graphene[*3], which has excellent nonlinear optical characteristics, with an extremely small nano-optical waveguide (plasmonic[*4] waveguide), we have demonstrated an all-optical switch that operates in the ultrafast range (less than one picosecond) with low energy consumption [3] (**Fig. 3**). What's more, topological photonics, which applies topological-field theory[*5] in solid-state physics to optics, is a new field of optics and expected to produce novel physical properties that we do not know what to do with yet. In this field, we theoretically discovered that a photonic topological insulator can be formed by current injection. This last topic is a more or less basic research, in which we cannot anticipate what will be discovered; thus, it is very exciting.

Our research is one of the technical directions outlined in the "Technology Development Roadmap for Realizing the IOWN (Innovative Optical and Wireless Network) Concept" announced in April 2020 [4]. To develop a cloud-computing infrastructure that seamlessly spans multiple datacenters, thereby contributing to achieving computing scaling across device, edge, and center cloud, we are engaged in basic research related to high-speed distributed-computing methods that use the ultrabroadband and low-latency communication on the All-Photonics Network.

Find interesting seeds, have fun, and communicate how interesting your research is with other people

—Could you tell us what you value when you do research?

What I value most when doing research is whether a theme is interesting. For example, we could not see any outcome when we started researching nanophotonics, but future applications were in sight after thoroughly investigating them. We are working on themes as a team, so if we find an interesting seed, someone on the team will substantiate it. All our research activities may seem successful because we have published the results of what we succeeded in pursuing, but, of course, some of our activities were failures. Sometimes we are more likely to fail. That's why research activities cannot continue unless the researchers themselves find them interesting. Also, unless other people think our activities are interesting, it may be difficult for the value of our research to

*3 Graphene: Carbon atoms arranged in a hexagonal lattice with thickness of one atom. Possessing high strength and hardness, it also has the property by which electrons flow faster than any other substance at room temperature.

*4 Plasmonics: A plasmon is a quantum of plasma oscillation. By controlling surface plasmons, which have states in which free electrons in the metal collectively oscillate and behave as pseudo particles, light can be propagated into nanocircuits and confined in a space much smaller than the wavelength of the light.

*5 Topological-field theory: A study of physical properties brought about by topology and symmetry.

be socially recognized. I sometimes talk with researchers in Europe and the United States at academic conferences. If I can't tell them what's interesting about my research and share my enthusiasm with them, I don't think they will become interested in it. Moreover, research activities will change according to phases and levels. It has been more than 10 years since my last interview. Last time, on finding new phenomenon, I first thought of combining nanophotonics and devices. The research phase and level then changed to applying nanophtonics to circuits then to processors. It took us about five years to ensure that nanophotonics could be useful, and since we knew what we could use, I discovered another interesting aspect of the phenomenon. It is said that matters progress like a spiral, but once certain research is complete, the process of rethinking and setting up is repeated. The interestingness is scattered throughout that process. When you are young, your research theme covers a narrow range; however, after doggedly doing your best, you gradually become able to handle several themes in parallel. Through close inquiry, targets of interest will appear one after another. However, I think that we should not let our research diverge according to our interests only. I also think that the number of things that we can handle will increase because we are working as a team. Therefore, we must be able to communicate how fascinating and interesting our research is. The more people you have on your team, the more ideas you will have.

—Is there anything you have done to improve yourself as a researcher?

I've been deliberately working on a new theme. Large and complex themes, especially, will not be pursued if we do not consciously work on them, which I think is an essential attitude a researcher should have. Researchers at NTT, especially those involved in basic research, may have a medium- to long-term perspective, and they can continue their research at their own pace and focus on the same subject throughout their time at NTT without any short-term pressure on producing results. However, if a researcher continues to study the same subject for a long time, he/she may get bogged down. At such times, I think we must have the courage to change the theme. I also think if we don't have the initiative to search for new themes, cross fields, or change departments, our feelings about and sensibilities of what is interesting will fade.

Now, the research that I am currently working on is aimed at fabricating an opto-electronic processor using integrated nanophotonics. We have been able to generate original results by collaborating with researchers in other fields. In the past, I didn't think I would collaborate with people in the electrical and circuit fields during my research; however, I have recently been working with researchers who originally had no experience in my research field.

Such a situation is somehow strange but very interesting. For example, different fields use different language. So, we first desperately speak in our own language, thus we cannot understand each other at all. After we talk many times, however, we start to understand each other. We learn the language of the other field and use it to talk about our own field. I find this process of gradually developing common words very interesting. I think it is important to continue our research while receiving this stimulus. If we don't pay attention to that stimulus, it will disappear, and we will not be able to produce original results.

—What does it mean to be a researcher? What is required for researchers today?

I think a researcher can be quite different from other professions. In most other professions, wages are paid for the results of the work; however, researchers are paid for what they are doing. Even if a researcher does not produce results; for example, even if they don't achieve anything for 10 years, it is difficult to evaluate their research work as meaningless. In addition, I think that if rewards are paid only for achievements, it will be difficult to maintain motivation, especially in the case of basic research with a long research span, which wouldn't allow us to even talk about interesting research. Given this consideration, it is necessary for researchers to engage in research every day with the awareness that they are rewarded for their research activities. Even if we do not know whether our research results will contribute to society, it is important to take up the challenge with the spirit and belief that we will contribute, and that is why I think being interested is an essential element of research activities.

Then, as I mentioned above, we will be asked to explain more about our research. It is important that our research be known as useful to society; it is even better if that research is reported in the mass media. Moreover, it would be great if we could share the interestingness of our research and the excitement about our daily research with the general public, but

that is probably too much to ask.

Let's venture into other fields and the world

—Please give a word to all our young researchers.

The number of research topics and fields has increased considerably, so it is difficult to follow them all; even so, I think it is very important to consciously attempt to understand other fields. It's easy to access information online, and young people, namely, "digital natives," are more accustomed to using the Internet than my "digital immigrant" generation, so I think they work in a good research environment. Unfortunately, I feel that over the past five years, young Japanese researchers have not as aggressively entered new research fields. Around the world, new fields and research themes are emerging one after another, and information about them is undoubtedly available, but young Japanese researchers have not ventured into these fields. I think that there are many excellent Japanese researchers, but in this situation, they will not able to obtain original results, and they will just rehash old ones. Therefore, I'd like our young researchers to watch out for new trends, be sensitive to information, and work hard.

So how do we take up a new research theme or field? One way is to knock on the gates of overseas research institutes. When I was in my mid-thirties, about 10 years after I started research, my boss told me, "Find your own research theme no matter what you do." So, I went to study in Sweden for a year, which was a very good experience. I think it's beneficial to take the opportunity to go abroad when you are young. In the past, being in academia in Japan enabled us to understand worldwide research trends, but the situation for giving research presentations is changing and includes online conferences. That's why I think it is necessary to go to international conferences held overseas and research institutes to directly communicate with many researchers.

It is also important to write papers and publish research results. Needless to say, peer review in the process of publication gives us a new perspective since the readers are also researchers. Ambiguousness may be allowed when reporting your achievements in your laboratory. When writing a paper, however, you must make the points of your arguments clear, so it helps to clarify your thoughts in the process of writing.

Moreover, considering various items through that argument may lead to new discoveries. You are probably curious about the number of citations your paper gets, but you should also be interested in how your paper was cited. When the paper is published, it is the result of what you thought of, but it then can be further developed, changed, and expanded through the interpretation of the other researchers who cite it. My paper titled "Theory of Light Propagation in Strongly-modulated Photonic Crystals: Refraction-like Behavior in the Vicinity of the Photonic Band Gap"—published in 2000 [5]—was cited in many other papers, and it became clear that antimatter affects certain physical phenomena. After that, the interpretation of my results spread further.

The number of papers you write each year depends on your research topic and environment, so you may not need to set a standard. In some institutes, like universities, the number of papers is significant, in others, such as in-house research institutes, the focus is on business promotion rather than papers. However, you won't necessarily finish your research life at the place you are now. Therefore, it is better to write papers so that you can be a researcher who can go anywhere and can clarify your research work and purpose.

—How will you proceed with your research activities in the future?

There were many prestigious research institutes but most do not exist today; for example, Bell Labs in the USA. NTT laboratories, in contrast, uniquely focus on everything from basic research to applied research. One can take up large research challenges because he/she has basic research and applied research in one institute. I want NTT to be a role model for other research laboratories as the number of laboratories that are firmly engaged in basic research decreases. However, I don't think we should be satisfied with doing research that general universities can do. I also have a laboratory at the Tokyo Institute of Technology, so I'd like to focus on nurturing the next generation of researchers. I think that the fields I'm working on will be enriched if I convey the knowledge I have accumulated and nurture those researchers. I can't accomplish everything myself, so I want new people to take the lead.

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■ **Interviewee profile**
Masaya Notomi
Senior Distinguished Scientist, Nanophotonics Center, NTT Basic Research Laboratories.

He received a B.E., M.E., and Ph.D. in applied physics from the University of Tokyo in 1986, 1988, and 1997. He joined NTT in 1988 where his research has focused on controlling the optical properties of materials/devices using artificial nanostructures (quantum wires/dots and photonic crystals). In addition to his work at NTT, he has also been a professor at the Department of Physics, Tokyo Institute of Technology since 2017. He received the IEEE/LEOS Distinguished Lecturer Award (2006) from the Institute of Electrical and Electronics Engineers/Lasers & Electro-Optics Society, the JSPS prize (2009) from the Japan Society for the Promotion of Science, a Japan Academy Medal (2009), and the Commendation for Science and Technology by the Japanese Minister of Education, Culture, Sports, Science and Technology (2010). Dr. Notomi is an IEEE Fellow and a member of the Japan Society of Applied Physics (JSAP), the American Physical Society (APS), and the Optical Society (OSA).

Publication of NTT Technology Report for Smart World 2020

Yuji Maeda, Takayuki Onishi, and Atsuyuki Muramoto

Abstract

NTT Research and Development Planning Department annually releases NTT Technology Report for Smart World, which presents 11 technologies that will transform technology into a natural presence and make the world smarter, and other leading-edge activities of NTT. It has now published the 2020 edition with new information added. This article presents an overview and the main updated points of the report.

Keywords: technology trend, social trend, smart world

1. For Smart World and Natural Technologies

The first edition of NTT Technology Report for Smart World was released in May 2019. It has been widely distributed both in hard-copy and as a download. It introduced 11 technologies that will make the world smarter and more natural. We have updated the technology report for the edition 2020 to reflect changes in technology trends and the progress in NTT's research and development (R&D) activities over the last year.

Artificial intelligence is now in practical use in many services. Such new technologies are bringing about dramatic changes in our living environment, such as the emergence of unmanned stores and automated driving, and digital transformation of business operations. The novel coronavirus, which has spread around the world in the last several months, is posing a great challenge to long-established economic and social systems and to connections between people. As exemplified by remote working and distance learning, information and communication technology (ICT) and communication networks are playing a significant role in supporting humanity's resilience. Looking to the future, it is essential to achieve breakthroughs in solving energy problems and developing innovative medical, materials, and manufacturing technologies. However, we cannot discuss using such technologies without considering their implication for cyber security and privacy protection.

The new edition of the technical report reviews the 11 technologies presented in last year's edition and introduces the latest technical trends and progress in NTT's R&D activities. It also explains the specific configuration and research roadmap of the Innovative Optical and Wireless Network (IOWN) and touches on the establishment of a global forum for IOWN.

2. Eleven Technologies to Update the Smart World

We are focusing our R&D efforts on 11 technologies that will transform technology into a natural presence and make the world smarter. From technologies that are already being implemented to promising technologies that are still in their infancy, we introduce how these 11 technologies will help to build the Smart World.

1. Artificial Intelligence

Progress in deep learning has made artificial intelligence (AI) the hottest topic of recent years. Its performance is already higher than that of humans when it comes to making classifications or judgements based on learning a large volume of data. What is required in the future is technology that operates based on an understanding of what is deep inside humans, such as emotion. In using AI, it will be necessary to consider people's worldviews and ethics. We are exploring the humanities in collaboration with

Kyoto University with an aim of developing AI that deeply understands and coexists with humans.

2. Virtual Reality / Augmented Reality

Virtual reality (VR) has long been used in games. Attention is now focused on new applications such as elderly care that uses VR to simulate excursions. In the future, VR and augmented reality (AR) will make its way into every facet of human life. Once the real world and cyberspace are integrated and people can seamlessly move back and forth between the two, VR/AR technology will play an even more important role. In the future, it will be necessary to provide people with feedback by reproducing the five senses and by digitizing and modelling people, objects, and environments in real time through more advanced sensing and information gathering in the real world. Achieving this in a natural way that does not burden people is a significant research challenge.

3. Human-Machine Interface

The range of uses for human-machine interface (HMI) will expand dramatically in environments where the real world and cyberspace are closely intertwined. The concept of "ambience" will be important as this field evolves. We are focusing on technology that unobtrusively presents information, and technology that uses information imperceptible to humans to provide natural support from the surrounding environment without hindering people's activities. To expand human activities in the real world, we will address challenges including how to maximize human motor function.

4. Cyber Security

The risks to network security from threats such as cybercrime and cyberterrorism are dramatically increasing. As the real world connects more closely with cyberspace, attacks on cyberspace are likely to result in substantial real-world impacts. To address these risks, we are developing technology that minimizes security damage while solving the issue of growing security-related operational costs. Furthermore, we are pushing forward on research to create better systems and norms by encouraging the inclusion of language consistent with technology in laws, and on a wide range of activities for building communities and developing human resources in the cybersecurity field.

5. Information Processing Infrastructure

We anticipate system control based on information from video and a variety of other sensors to enable optimal behavior selection and future prediction that exceeds human capabilities in a range of fields. However, as we work to establish a sustainable society, we are confronted with a number of issues, such as abrupt changes in the requirements for data processing and high levels of power consumption. Using data-centric information processing infrastructure and optical technology, we are striving to exceed the limits of existing infrastructure and create technology that can process enormous amounts of data from the real world at low latency. We are calling this approach "phygital data-centric computing."

6. Networks

It goes without saying that networks form the foundation of the Smart World. While attention has focused in recent years on network virtualization and decentralized networks, conventional networks based on electronic processing technology are approaching their limits. To address this problem, we are shifting to photonics-based technology to create networks that can address current challenges and achieve low energy consumption, high quality, large capacity, and low latency. Moreover, we are rapidly expanding the scope of network connections, including via satellite communication utilizing MIMO (multiple-input and multiple-output) and conducted in collaboration with JAXA, as well as undersea communications.

7. Energy

In an era when companies around the world are striving to achieve sustainable development goals and people's environmental awareness is rapidly changing, major breakthroughs are needed in research and development in the energy field. We are developing technology for using renewable energy efficiently and reliably by merging our power system and network technologies. We are also working to develop communication equipment that can operate with micro-energy. In addition, we are embarking on harnessing innovative energy sources, including fusion power, space solar power, and lightning charging, all of which are long-cherished dreams of humankind.

8. Quantum Computing

Quantum computing technology, known for its vastly greater power than conventional computers, is anticipated to be introduced in nearly every industry. Companies in the U.S., Europe, China, and elsewhere are pushing ahead with development of their own computers. To develop innovative computing

technologies, we are taking a number of approaches to next-generation information processing: from von-Neumann-type post-Moore computing, and non-von-Neumann-type post-Moore computing to rapid and efficient quantum information processing based on new principles, looking beyond even post-Moore technology.

9. Biotechnology / Medical Care

Biomedical technology is no longer developed solely within biology, chemistry, or medicine. As the real world and cyberspace increasingly merge together, the scope of biomedical technology will also expand. An example is precision medicine and personalized medicine that is realized through the integration of ICT and AI. We are aiming to realize natural, data-driven medicine and healthcare. For this purpose, we are using AI to predict potential disease risks and to elucidate the mechanisms of disease, and developing high-precision, real-time biomonitoring technologies and new materials that blend naturally into the living body. Through such a multi-faceted approach, we will open a promising path toward a prosperous future for biotechnology and medical care.

10. Advanced Materials

Companies around the world are pouring resources into the pursuit of advanced materials. Examples include ultrafine materials, nanomaterials, multifunctional materials, and environment-adjustable materials, all of which are key to next-generation biotechnology and memory technology. We have established three overall strategic directions: (1) devices that help reduce power consumption and latency in optical communication, (2) materials that make people feel natural and creative, and (3) materials and devices with emergent novel functions. The development of advanced materials will continue in tandem with other technologies.

11. Additive Manufacturing

The term additive manufacturing likely brings 3D printers to mind, but today the meaning of manufacturing is broader than ever before. We believe that the future will bring three changes: the personalization of biomedical devices, the maturation of photonics-electronics convergence devices, and the realization of unrivaled manufacturing technology at the nano scale. We will push ahead with the creation of artificial body systems, the manufacturing of advanced, complex photonics-electronics convergence devices, and the development of nano-level manufacturing technologies, including those that will make it possible to control arrays of atoms in three dimensions and those that will enable direct manipulation of atoms.

3. IOWN is the Platform for Our Future

Last year, we announced our vision for a new communication infrastructure known as IOWN to shift from electronics to photonics and develop "natural" technologies that go beyond the limit of today's digital technology. IOWN is composed of three main elements: (1) the All-Photonics Network (APN), which employs photonics-based technology for everything from networks to terminals; (2) Cognitive Foundation® (CF), which connects and controls everything; and (3) Digital Twin Computing (DTC), which enables future prediction by integrating the real and digital worlds.

In October 2019, we joined with partners Intel and Sony to announce the establishment of the IOWN Global Forum. Through this framework, we are pressing ahead with R&D with global partners. We also released our IOWN technology development roadmap in April 2020. This roadmap is also explained in the technology report.

4. Conclusion

NTT Research and Development Planning Department will continue to annually release a summary of technology trends, and the strategies and activities of NTT R&D. The document released and summarized above is presented on the NTT R&D website [1].

Reference

[1] NTT Technology Report for Smart World 2020, https://www.rd.ntt/e/techreport/

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He received a Ph.D. in systems information science from Future University Hakodate, Hokkaido, in 2013. He joined NTT Telecommunication Networks Laboratories in 1991. He is currently managing projects related to general emergency management such as those concerning natural disaster response and cybersecurity involving NTT-CERT. He received the Scholarship Encouragement Award from the Institute of Electronics, Information and Communication Engineers (IEICE) in 1998. He is a senior member of IEICE and a member of the Institute of Electrical and Electronics Engineers (IEEE) and the Japanese Telemedicine and Telecare Association.
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Standardization Activities for Optical Fiber and Cable Technology in International Electrotechnical Commission

Takashi Matsui, Yusuke Yamada, and Noriyuki Araki

Abstract

The International Electrotechnical Commission Technical Committee 86 (IEC TC 86) is a standards development organization that prepares and decides on international standards in relation to products used for optical fiber communication. In this article, we provide an overview of standardization activities, introduce topics discussed at meetings in 2019 and 2020, and describe the Japanese standardization strategy in IEC TC 86.

Keywords: IEC, optical fiber, international standard

1. Introduction

The International Electrotechnical Commission (IEC) is a standards development organization that sets all of the required standards for electrical and electronics technologies. In IEC, a Technical Committee (TC) is established for each technical field and holds detailed discussions on the contents, publication, and revision of international standards. TC 86 handles specifications and test methods of optical products in optical communication systems. NTT is researching and developing technologies and requirements for optical communication systems and actively participating in IEC TC 86 standardization activities since international standards are closely related to equipment procurement and interconnection. NTT's activity involves making proposals for international standardization and discussing documents to guarantee the quality and interoperability of telecommunication networks and product specifications used in Japan. The International Telecommunication Union - Telecommunication Standardization Sector (ITU-T) Study Group (SG) 15 is also discussing international standardization for optical fibers and cables from the viewpoint of requirements for public communication network systems, and NTT is also actively participating in this. In IEC, standardization is mainly conducted from the viewpoint of consistency between procurement specifications for optical products and international standards, and in ITU-T, standardization is being discussed from the viewpoint of securing interoperability of communication systems and requirements. Standardization activities of IEC and ITU-T are being promoted in close cooperation with each other.

In IEC, TC 86 is in charge of fiber optics technology and its main objective is to establish standards such as optical, environmental, and mechanical requirements of fiber optics products for optical fiber systems, such as optical modules and devices used with optical fiber cables, connectors, and communication equipment. The technical fields of TC 86 are shown in **Fig. 1**, and its organizational structure is shown in **Fig. 2**. TC 86 has three Subcommittees (SCs) and makes decisions in each technical field. SC 86A is in charge of optical fibers and cables, SC 86B is in charge of optical connecting and passive devices, and SC 86C is in charge of optical subsystems and

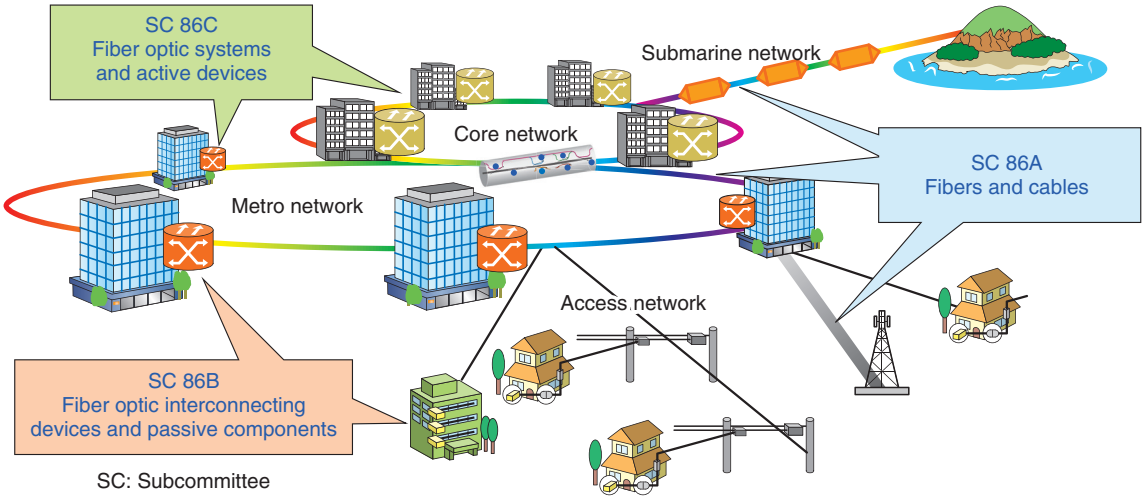


Fig. 1. Technical fields of IEC TC 86.

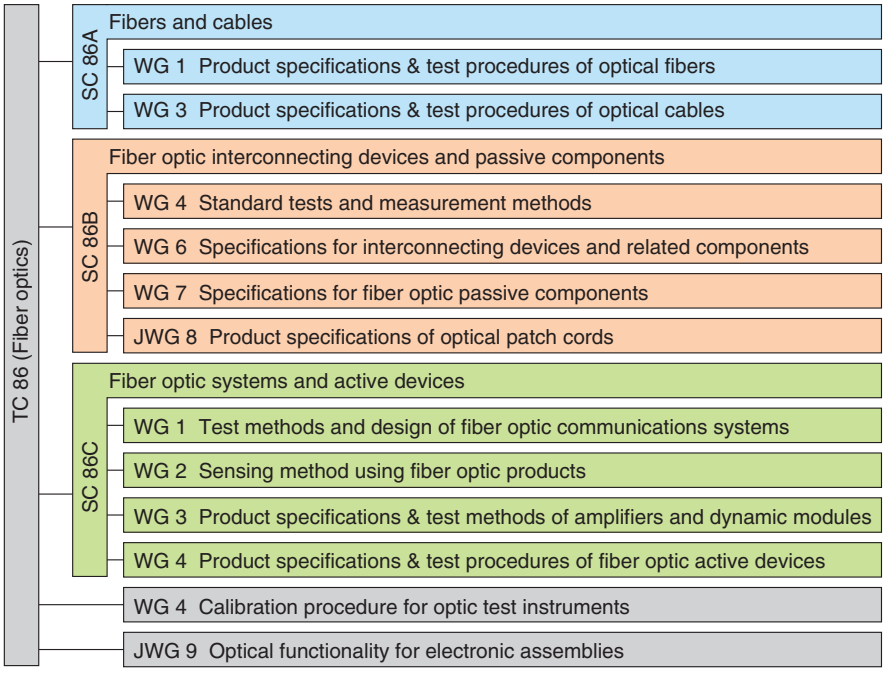
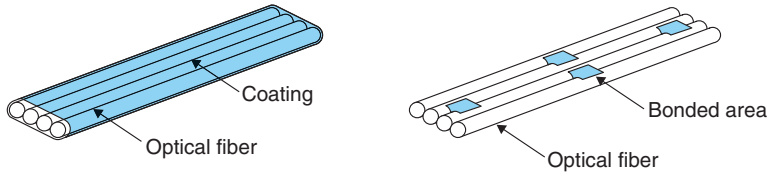


Fig. 2. SCs and Working Groups (WGs) of IEC TC 86.

active devices. It also has 12 Working Groups (WGs) to discuss specific standards documents. Each WG proposes new or revised standards for the technical field it is in charge of and prepares documents, which are then issued and reviewed by each SC. This article describes recent trends in optical fiber and cable standards being discussed in IEC.

2. Recent trends in standardization for optical fiber and cable technology

In the field of fiber optics, which IEC TC 86 is



(a) Conventional optical fiber ribbon (b) Partially bonded optical fiber ribbon

Fig. 3. Structure of optical fiber ribbon.

responsible for, discussions on the standardization of optical cables and connecting devices for access systems have been active, especially against the background of the rapid increase in demand for optical fiber cables in datacenters and the rapid spread of FTTH (fiber to the home) in Europe and emerging countries. In SC 86A, which handles optical fiber cable standards, revisions are being made to optical fiber and optical fiber ribbon standards in line with the increasing fiber count and high density of optical cables, and proposals and discussions are being made on various testing methods for optical cables in consideration of the usage environment in each country.

A new standardization of the partially bonded optical fiber ribbon, which was developed using ultra-high-density optical cables, and new test methods for the friction coefficient and freezing characteristics of optical cables were proposed by Japan and agreed upon in SC 86A.

Figure 3 shows an example of the structure of an optical fiber ribbon. Conventional optical fiber ribbons have restricted flexibility in handling because they cover multiple optical fibers in a unified manner. A partially bonded optical fiber ribbon has greatly improved flexibility, such as being able to be rounded or bent in any direction, by being bonded discretely in the longitudinal direction. Since the size and test method were specified on the assumption that the conventional optical fiber ribbon would not deform, the standard was revised to allow consideration of the partially bonded optical fiber ribbon, and a new standard document was published as IEC 60794-1-31. The partially bonded optical fiber ribbon enables the increase in the mounting density of optical fiber in optical cables to the upper-most limit, has been used for ultra-high-density optical cables in Japan, and has recently begun to be used for densifying high-count optical cables in other countries.

Standards for optical cable testing methods are also essential to objectively guarantee optical cable characteristics. In Japan, low-friction indoor cables have been developed and introduced for indoor wiring, but because there is no standard test method for the friction coefficient of optical cables, it is difficult to objectively judge the performance of similar products. **Figure 4** shows the friction coefficient test method for optical cables proposed by Japan. This method is based on the method of testing the coefficient of friction between plastic films and was developed by NTT. As the number of optical cables to be installed overseas has increased, the friction between optical cables has attracted a great deal of attention, and an agreement was reached to establish a new standard as one of the methods for testing the mechanical properties of optical cables.

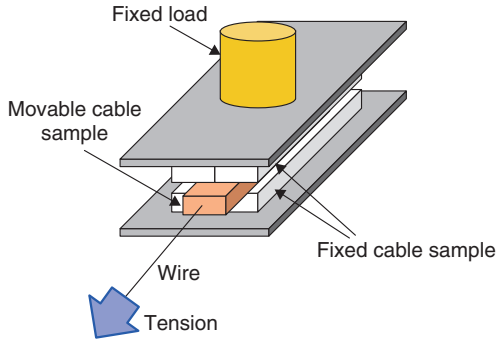


Fig. 4. Test procedure of friction coefficient for optical indoor cable.

In addition, Japan proposed a new test method to evaluate the freezing characteristics of an optical cable considering its installation in a cold region. The proposed test method, shown in **Fig. 5**, was designed to test the characteristics of an optical cable by installing the optical cable in a water-filled conduit, cooling it, and simulating the freezing environment in the conduit where the optical cable is actually installed. NTT is installing and operating optical

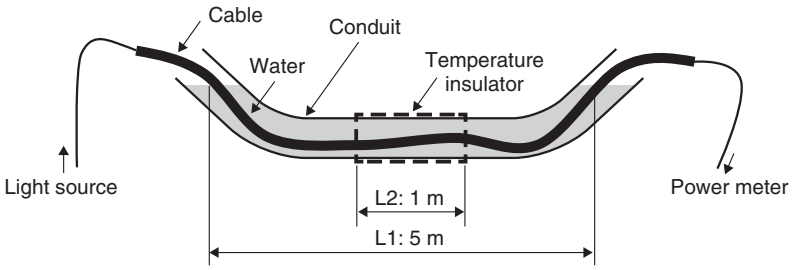


Fig. 5. New frozen test procedure of optical cable.

cable facilities in various environments in Japan. The optical cables used in these facilities are evaluated using this test method, and the necessary conditions for countermeasures are specified. There are few examples of knowledge and proposals concerning the frozen environment, and it has attracted a great deal of interest from the participating countries.

These new optical fiber cable standards enable us to expand Japanese technology worldwide, eliminate inferior products, and objectively guarantee the characteristics of optical cables in the user's environment.

3. Further activities

Japan has aggressively promoted the domestic deployment of optical fiber and cable technology and has a strong presence as one of the major countries in IEC TC 86. Based on NTT's extensive experience and knowledge in the introduction and operation of optical fiber and cable technology, NTT will contribute to the development of international standards that contribute to the development of optical communication networks by closely cooperating with ITU-T. NTT will also promote the establishment of next-generation optical fiber and cable technology, which will be indispensable for the implementation of the Innovative Optical and Wireless Network (IOWN) through both research and development and standardization activities.

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Snow-accretion-prevention Sheet for Outdoor Aerial Closure

Technical Assistance and Support Center, NTT EAST

Abstract

When snow accumulates on closures, it will repeatedly melt and freeze, gradually changing into solid blocks of ice. These ice blocks may fall from closures and damage vehicles below. This article introduces a snow-accretion-prevention sheet that enables snow to fall off closures before it forms ice blocks. This is the fifty-ninth article in a series on telecommunication technologies.

Keywords: snow accretion, closure, snow-accretion-prevention sheet

1. Introduction

Snow accretion frequently occurs on overhead equipment during winter in Japan. When snow continues to accumulate on the upper surface of the housing (sleeve) of closures, it will repeatedly melt and freeze, gradually changing into dense hard blocks of ice. These ice blocks may fall from closures and damage vehicles, as shown in **Fig. 1**. Consequently, in regions with heavy snowfall, maintenance workers have to regularly remove snow from closures to prevent such problems. In such heavy-snowfall regions, measures against snow accretion on closures have therefore become urgent.

With the above issue in mind, the Technical Assistance and Support Center (TASC), NTT EAST, introduced a countermeasure to prevent snow from accumulating on closures in a previous article [1]. This article presents outline of the technology for preventing snow accretion and the results of a performance verification of the technology involving an outdoor exposure test and describes the procedure for implementing the technology on site.

Fig. 1. Snow accretion on a closure and property damage.

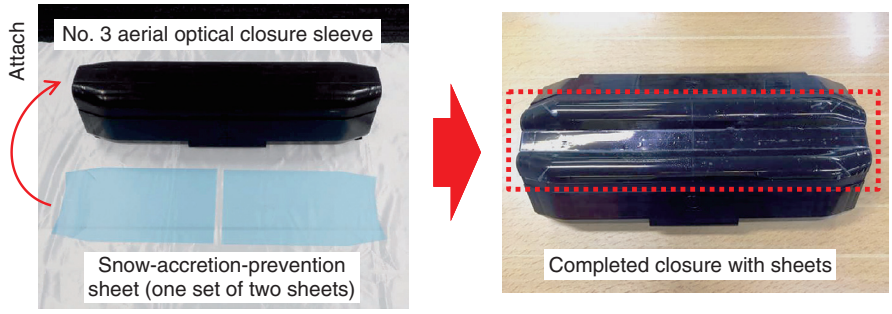

Fig. 2. Closure with the snow-accretion-prevention sheet.

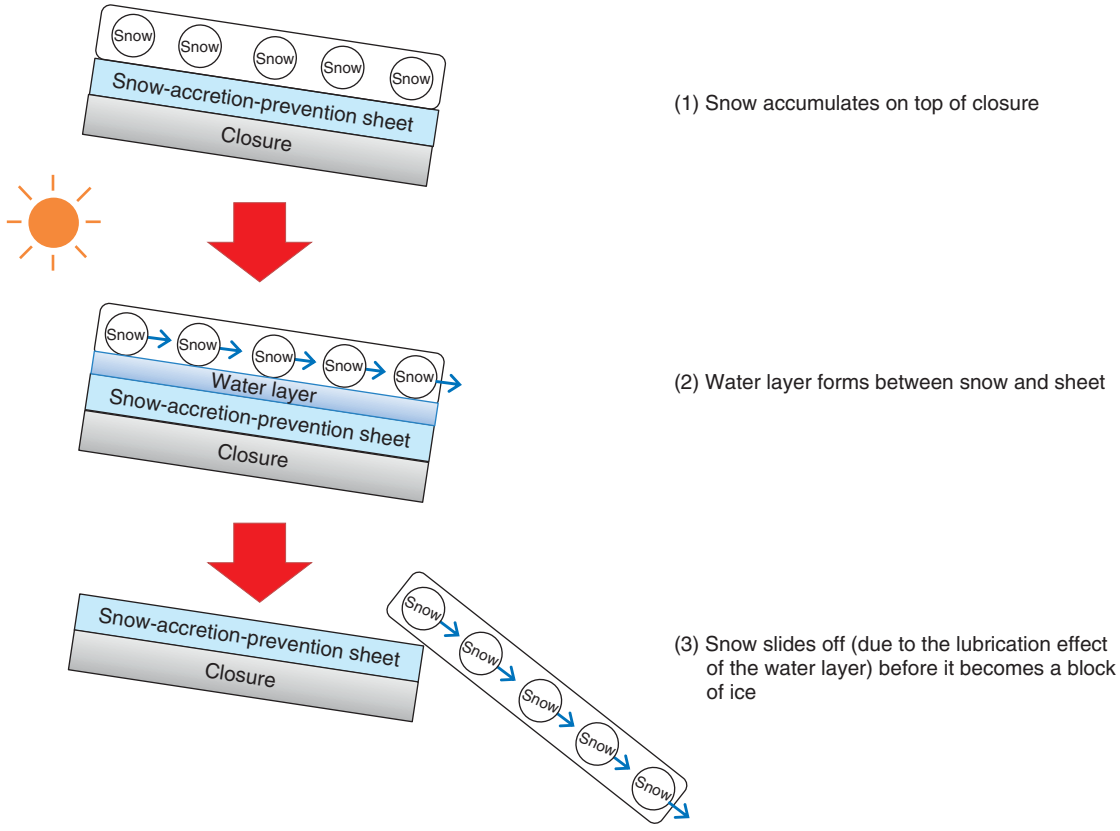

Fig. 3. Process of preventing snow accretion using the sheet.

2. Outline of technology for preventing snow accretion

To prevent snow from accumulating on a closure, a special adhesive sheet with a hydrophilic surface—called a snow-accretion-prevention sheet Nichiban Co., Ltd.—is used, as shown in **Fig. 2**. When wet snow falls, i.e., snowfall that contains a large amount of moisture, accumulates on the sheet, a water layer forms between the sheet and snow. The lubrication effect of the water layer makes it possible to prevent accidents by making the snow fall from the closure before it becomes a solid block of ice, as shown in **Fig. 3**. As often seen in regions along the Sea of Japan such as Yamagata and Niigata prefectures, such wet snowfall mentioned above easily attaches to objects [2].

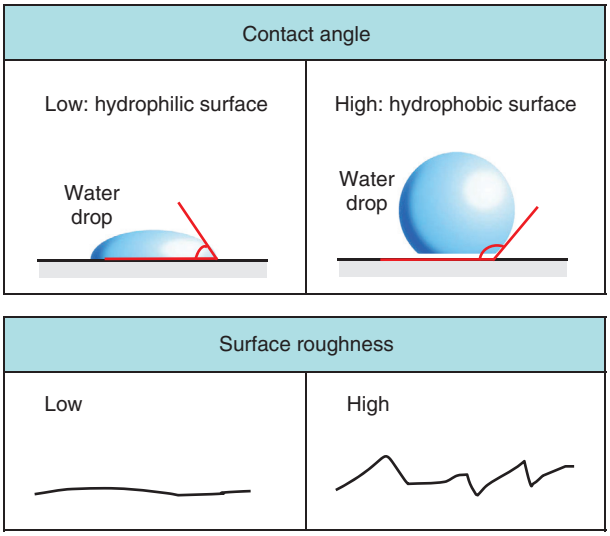

Fig. 4. Performance parameters of the snow-accretion-prevention sheet.

3. Performance verification of the snow-accretion-prevention sheet

3.1 Exposure test

To confirm that the performance of the snow-accretion-prevention sheet is maintained even after it is subjected to exposure of natural phenomena such as ultraviolet rays in the summer or wind and rain, including typhoons, an outdoor-exposure test was carried out. The test was conducted in Yonezawa City, Yamagata Prefecture, where heavy wet snowfall often occurs. The verification period of the exposure test was three years, which is the expected quality-assurance period of the sheet. Two verification items were selected: (i) performance parameters (**Fig. 4**) of the sheet after exposure for three years and (ii) snow-accretion condition based on video images. The contact angle with water, which is one of the indices for evaluating the wettability of a substance's surface, represents the swelling of a water droplet (i.e., angle of water droplet) that occurs when it is dropped on a substance. A high and a low value indicate a hydrophobic and a hydrophilic surface, respectively. A hydrophilic surface is suitable for the sheet because its hydrophilicity makes it easy to form a water layer between accumulated snow and the sheet. Moreover, low surface roughness reduces the friction between the snow and sheet, making it easier for the snow to slide. During the exposure test, videos of the closures installed at the test site, two with the snow-accretion-prevention sheet and the other without, were recorded to observe the difference in snow accretion due to the presence or absence of the sheet.

3.2 Test results

The rate of change in the performance parameters (contact angle and surface roughness) after the three-year exposure test are plotted in **Fig. 5**. Under the assumption that the initial values are 1, the performance of the snow-accretion-prevention sheet is maintained when the rate of change of the contact angle is 1.6 times or less and that of surface roughness is 5.0 times or less. Figure 5 indicates that the contact angle and surface roughness remained in the range in which snow-accretion-prevention performance was maintained, even after exposure for three years. In the left photograph of **Fig. 6**, the same amount of snow accretion was observed on both types of closures (two with and one without the snow-accretion-prevention sheet); however, in the right photograph taken two hours after the left photograph, only the closures with the sheet lost their snow. This result suggests that a closure with the snow-accretion-prevention sheet is more likely to make accumulated snow slide off (thus less likely to cause snow clumping into ice blocks) compared to a closure with no sheet. The above results confirm that the physical properties of the surface of the snow-accretion-prevention sheet (such as contact angle) did not significantly change, and snow falling from the closures was regularly observed during the test period; therefore, the performance of the snow-accretion-prevention

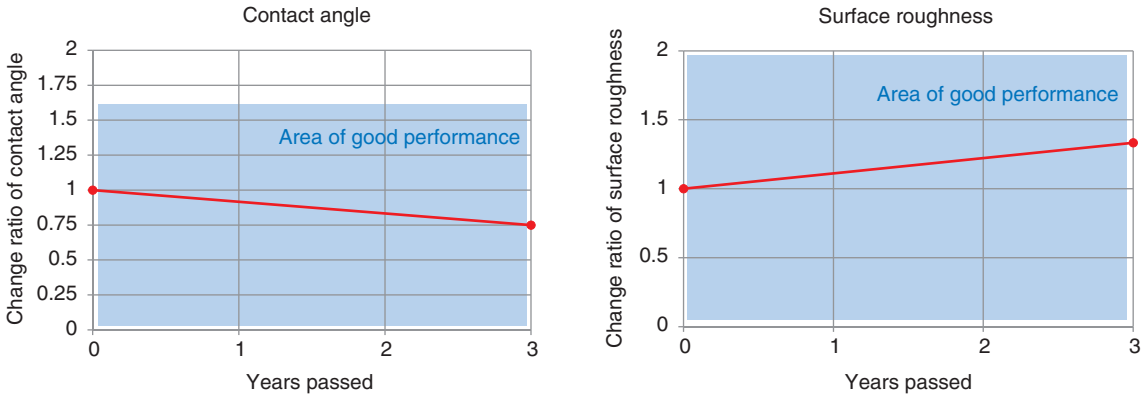

Fig. 5. Transition in performance parameters.

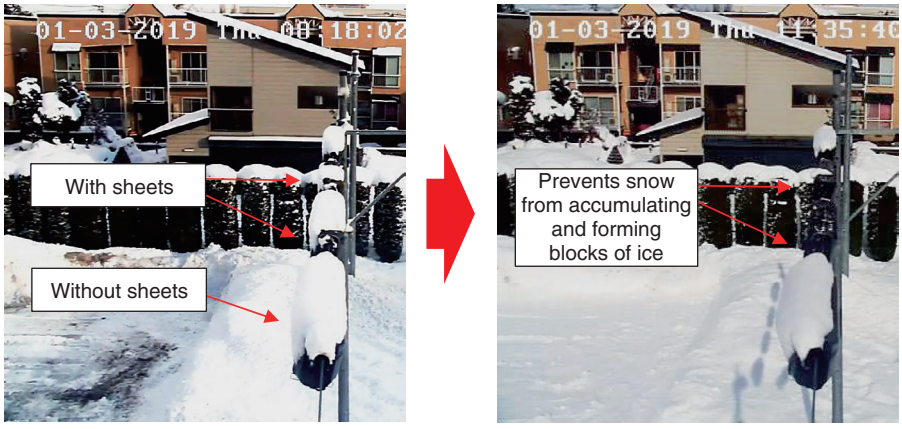

Fig. 6. Exposure field test.

sheet was maintained for three years.

4. Sheet-attachment procedure

One of the advantages of implementing the snow-accretion-prevention sheet is that it can be attached quickly without requiring any particular skill. The procedure for attaching the sheet to a closure is described as follows (see **Fig. 7**).

(1) Prepare the closure sleeve, snow-accretion-prevention sheet (one set of two sheets), and a cloth for cleaning the upper surface of the sleeve to remove dirt before applying the sheet. Peel off the release sheet along the center line of the back of one snow-accretion-prevention sheet and attach the adhesive side of the sheet to the sleeve (so it will be temporarily fixed).

(2) Peel off half of the release sheet from the back side of the snow-accretion-prevention sheet and attach the sheet to the sleeve. Take care not to create irregularities or bubbles when applying the sheet. Repeat for the other half of the surface on the closure sleeve.

(3) Attach the other snow-accretion-prevention sheet in the same manner as in steps (1) to (3).

(4) Finally, peel off the protective film (blue) on the surface of each sheet (completed closure is shown in Fig. 2). Take care not to directly touch the sheet surface after peeling off the protective film (doing so will reduce the snow-accretion-prevention performance of

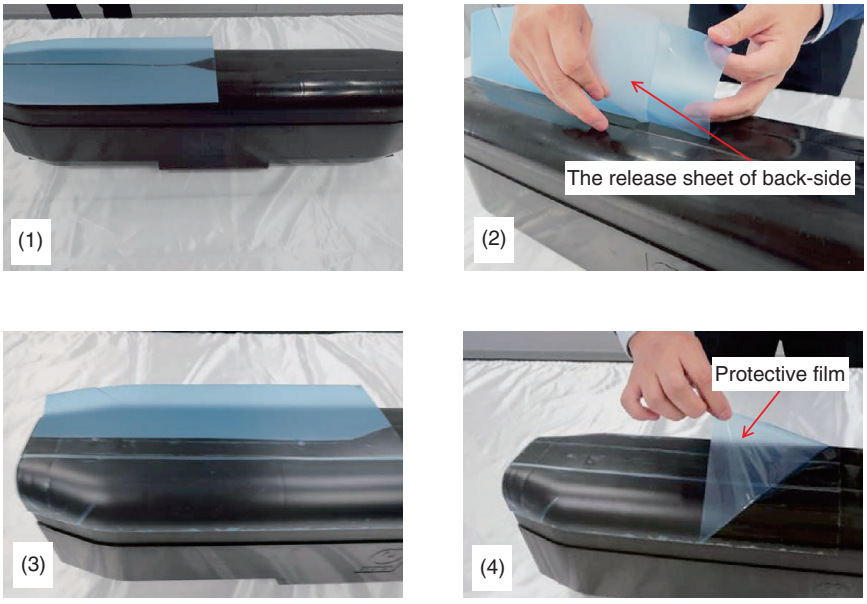

Fig. 7. Procedure for attaching the snow-accretion-prevention sheet.

the sheet).

5. Conclusion

The snow-accretion-prevention sheet can be attached to a closure to allow snow to fall off the closure before it forms an ice block. Thus, it prevents equipment problems and accidents due to snow falling off the closure. An outdoor exposure test confirmed that the performance of the snow-accretion-prevention sheet can be maintained for three years. This sheet can be installed by simply attaching it to the closure.

The TASC will continue to promote technical cooperation activities aimed at solving on-site issues and contribute to improving the quality and reliability of telecommunication facilities.

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[2] Y. Matsushita and F. Nishio, "Climatological Characteristics Corresponding to the Occurrence of Precipitation Resulting in Snow Accretion in Japan," Journal of the Japanese Society of Snow and Ice, Vol. 68, No. 5, pp. 425–426, 2006.

External Awards

CSS2019 Encouragement Award
Winner: Taishi Nishiyama and Atsutoshi Kumagai, NTT Secure Platform Laboratories; Akinori Fujino, NTT Communication Science Laboratories; Kazunori Kamiya, NTT Secure Platform Laboratories
Date: October 23, 2019
Organization: Information Processing Society of Japan (IPSJ)

For "pAUC Maximization Method for Malware Detection."
Published as: T. Nishiyama, A. Kumagai, A. Fujino, and K. Kamiya, "pAUC Maximization Method for Malware Detection," Computer Security Symposium 2019, Nagasaki, Japan, Oct. 2019.

SCIS Paper Award
Winner: Ibuki Mishina, NTT Secure Platform Laboratories
Date: January 28, 2020
Organization: The Institute of Electronics, Information and Communication Engineers (IEICE) Technical Committee on Information Security (ISEC)

For "Can the Logistic Regression in Secure Computation Really Be Used?".
Published as: I. Mishina, "Can the Logistic Regression in Secure Computation Really Be Used?", 2019 Symposium on Cryptography and Information Security, Shiga, Japan, Jan. 2019.

NDSS 2020 Distinguished Paper Award
Winner: Takuya Watanabe, NTT Secure Platform Laboratories/ Waseda University; Eitaro Shioji and Mitsuaki Akiyama, NTT Secure Platform Laboratories; Tatsuya Mori, Waseda University
Date: February 26, 2020
Organization: Internet Society (ISOC)

For "Melting Pot of Origins: Compromising the Intermediary Web Services that Rehost Websites."
Published as: T. Watanabe, E. Shioji, M. Akiyama, and T. Mori, "Melting Pot of Origins: Compromising the Intermediary Web Services that Rehost Websites," Proc. of the 27th Annual Network and Distributed System Security Symposium (NDSS 2020), San Diego, CA, USA, Feb. 2020.

Young Researcher's Award
Winner: Asuka Matsushita, NTT Network Innovation Laboratories
Date: March 19, 2020
Organization: IEICE

For "Nonlinear Response Compensation for Digital Coherent Optical Receiver."
Published as: A. Matsushita, M. Nakamura, S. Kuwahara, K. Horikoshi, S. Okamoto, and H. Nishizawa, "Nonlinear Response Compensation for Digital Coherent Optical Receiver," Proc. of the 2019 IEICE Society Conference, B-10-28, Osaka, Japan, Sept. 2019.

The Young Scientists' Prize, the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology
Winner: Dai Ikarashi, NTT Secure Platform Laboratories
Date: April 7, 2020
Organization: Ministry of Education, Culture, Sports, Science and Technology, Japan

For his research on privacy protection technology that balances data utilization and protection.

Distinguished Service Award
Winner: Haruka Eitoku, NTT Network Service Systems Laboratories
Date: May 14, 2020
Organization: The Telecommunication Technology Committee (TTC)

For his contribution to the formulation of the common interconnection interface for SIP (Session Initiation Protocol) domain name resolution using the domain name system in TTC and the corresponding standardization work in 3GPP.

Distinguished Service Award
Winner: Takeshi Seki, NTT Network Service Systems Laboratories
Date: May 14, 2020
Organization: TTC

For his contribution to the international standardization concerning equipment functions and protection/restoration of transport networks.

Distinguished Service Award
Winner: Kaoru Arai, NTT Network Service Systems Laboratories
Date: May 14, 2020
Organization: TTC

For his contribution to the international standardization concerning time- and frequency-synchronization technology for packet transport networks.

Best Paper Award
Winner: Daisuke Sato, Tatsushi Matsubayashi, Masato Fukuda, Kyota Tsutsumida, NTT Service Evolution Laboratories; Akira Nakayama, NTT Research and Development Planning Department; Hiroyuki Toda, NTT Service Evolution Laboratories
Date: May 23, 2020
Organization: The 12th Forum on Data Engineering and Information Management (DEIM2020)

For "Composite Spatio-temporal Prediction Model Using Residual Regression."
Published as: D. Sato, T. Matsubayashi, M. Fukuda, K. Tsutsumida, A. Nakayama, and H. Toda, "Composite Spatio-temporal Prediction Model Using Residual Regression," DEIM2020, Fukushima, Japan, Mar. 2020.

Award from Chairman of the Council for Info-communications Promotion Month
Winner: Yoshinori Goto, NTT Network Technology Laboratories
Date: May 29, 2020
Organization: The Council for Info-communications Promotion Month, Ministry of Internal Affairs and Communications

For his contribution to the promotion of international standardization in the International Telecommunication Union - Telecommunication Standardization Sector (ITU-T).

12th Special Activity Award

Winner: Katsuhiro Ajito, NTT Device Technology Laboratories
Date: June 4, 2020
Organization: The Institute of Electrical Engineers of Japan (IEEJ)

For his contribution to the activation of research activities through the SENSOR SYMPOSIUM on Sensors, Micromachines and Applied Systems and the improvement of IEEJ's business presence through collaboration with other academic societies and the local host communities. This award was given to the executive committee of the SENSOR SYMPOSIUM on Sensors, Micromachines and Applied Systems.

Best Late-Breaking Report Honorable Mention Video Award

Winner: Mitsuhiro Goto, Masanori Yokoyama, and Yumiko Matsuura, NTT Service Evolution Laboratories
Date: June 9, 2020
Organization: 15th Annual IEEE/ACM International Conference on Human-Robot Interaction (HRI 2020)

For "Impression Evaluation of Presentation by a Communication Robot in an Actual Exhibition."
Published as: M. Goto, M. Yokoyama, and Y. Matsuura, "Impression Evaluation of Presentation by a Communication Robot in an Actual Exhibition," Proc. of HRI 2020, pp. 218–220, Mar. 2020.

Technical Committee on Communication Quality Research Encouragement Award

Winner: Yuichiro Urata, Masanori Koike, and Kazuhisa Yamagishi, NTT Network Technology Laboratories
Date: July 16, 2020
Organization: IEICE Technical Committee on Communication Quality

For "An Applicability of ITU-T Recommendation P.1203 Model to VR Video Streaming."
Published as: Y. Urata, M. Koike, and K. Yamagishi, "An Applicability of ITU-T Recommendation P.1203 Model to VR Video Streaming," IEICE Tech. Rep., Vol. 119, No. 125, CQ2019-52, pp. 79–83, July 2019.

Papers Published in Technical Journals and Conference Proceedings

Effects of Rosin-powder Application on the Frictional Behavior Between a Finger Pad and Baseball

T. Yamaguchi, N. Yamakura, S. Murata, T. Fukuda, and D. Nasu
Frontiers in Sports and Active Living, Vol. 2, 30, April 2020.

Rosin powder, which is composed of magnesium carbonate powder and pine resin, is often used as a grip-enhancing agent in baseball pitching. However, the effect of rosin powder on friction at the baseball–human finger interface remains unclear. This study aimed to investigate the effect of rosin powder on the friction coefficient between a baseball and finger using sliding friction tests. Ten young adult males participated in this studyand were asked to slide the index finger of their dominant hand over the leather skin of a baseball adhered to the force sensor, which was not a real baseball pitching situation. Our findings suggest that rosin-powder application stabilizes friction under both dry and wet conditions, that is, there was less dependence of the friction coefficient on the normal force and less variation in the friction coefficient among individuals. For most participants, the friction coefficient was not necessarily increased by the presence of rosin powder at the finger pad–leather sheet interface under dry conditions. However, under wet conditions, rosin-powder application increased the friction coefficient compared with under the non-powdered condition in the large normal force condition, indicating the efficacy of rosin powder as a grip-enhancing agent.

Behavioral Measures in a Cognitive-motor Batting Task Explain Real Game Performance of Top Athletes

D. Nasu, M. Yamaguchi, A. Kobayashi, N. Saijo, M. Kashino, and T. Kimura
Frontiers in Sports and Active Living, Vol. 2, 55, May 2020.

Excellent athletic performance in baseball and softball batting is achieved through the momentary cognitive-motor processes. However, in previous studies, cognitive and motor processes were investigated separately. In this study, we focused on the difference in the time of swing onset (a delta onset) during a batting task where 17 elite female softball batters hit balls randomly thrown at two different speeds by pitchers. The delta onset included both cognitive and motor processes because the batters needed to anticipate the ball speed and discriminate their swing motion according to the time-to-contact. Then, we investigated the relationship between the delta onset and batting outcomes of the batting task and the relationship between the experimental outcomes and actual batting performance (batting average) over a season.We used path analysis to clarify the structure of the cognitive-motor processes and consequent performance. We found that the batters who had a larger delta onset attained superior batting outcomes (i.e., higher exit velocity and lower miss ratio) in the batting task, and these experimental outcomes explained 67% of the batting average in real games. On the other hand, the cognitive scores (judgement accuracy and rapidity) obtained from a button pressing task, where batters responded to a ball by pressing a button instead of actually swinging, explained only 34% of the batting average.

Therefore, our model quantitatively describes the key cognitive-motor structure for athletes and can partially predict a batter's performance in real games. These findings suggest that it is important to employ both cognitive and motor processes in performing tasks, such as this batting task, to properly evaluate a batter's actual ability.

Classification of Viewing Abandonment Reasons for Adaptive Bitrate Streaming

S. Takahashi, K. Yamagishi, P. Lebreton, and J. Okamoto

The 12th International Conference on Quality of Multimedia Experience (QoMEX), May 2020 (online).

As adaptive bitrate streaming services have spread, it has become more important for video streaming providers to control video quality and prevent viewing abandonments. However, since viewing abandonments are caused not only by quality degradations but also by a lack of users' interest in contents, it will first be necessary to clarify how quality and/or content affect viewing abandonments. To investigate this, we conducted an adaptive bitrate streaming experiment and developed a viewing-abandonment-reason-classification model that classifies abandonment reasons into quality or content. Using training data, we developed four models (logistic regression, classification tree, random forests, and support vector machine) where feature variables related to application quality, users' operation behaviors, and the attributes of viewed contents were used as explanatory variables. These four models were validated by using validation data. From the results, the support vector machine model was considered to be the best since it obtained relatively good validation results and did not appear to be overtrained.

Discontinuous and Smooth Depth Completion with Binary Anisotropic Diffusion Tensor

Y. Yao, M. Roxas, R. Ishikawa, S. Ando, J. Shimamura, and T. Oishi

arXiv:2006.14374 [cs.CV], June 2020.

We propose an unsupervised real-time dense depth completion from a sparse depth map guided by a single image. Our method generates a smooth depth map while preserving discontinuity between different objects. Our key idea is a Binary Anisotropic Diffusion Tensor (B-ADT), which can completely eliminate the smoothness constraint at intended positions and directions by applying it to variational regularization. We also propose an Image-guided Nearest Neighbor Search (IGNNS) to derive a piecewise constant depth map, which is used for B-ADT derivation and in the data term of the variational energy. Our experiments show that our method can outperform previous unsupervised and semi-supervised depth completion methods in terms of accuracy. Moreover, since our resulting depth map preserves the discontinuity between objects, the result can be converted to a visually plausible point cloud. This is remarkable since previous methods generate unnatural surface-like artifacts between discontinuous objects.

User Evaluation of Expression and Representation of Privacy Policy's Content

S. Shinoda, F. Magata, A. Fujimura, S. Kubota, and N. Chiba

IPSJ Journal, Vol. 61, No. 6, pp, 1146–1174, June 2020.

Recently, many online services are being provided for digital devices. Service providers collect a lot of users' personal data through these online services and process them for various purposes. They provide a privacy policy to give users opportunities to access the information about their data processing. However, in most cases, the privacy policy is too long and contains too many legal terms for the average user to understand. As the best way to express and represent a privacy policy's content remains unclear, some service providers have trouble designing one, and some intend to hide their privacy policies. For both protecting user privacy and promoting service providers' business, it is important to reveal how users react to expression and representation of privacy policy. To investigate this, we conducted a focus group interview and web survey then evaluated some privacy policy expressions and representations.

Polylog-overhead Highly Fault-tolerant Measurement-based Quantum Computation: All-Gaussian Implementation with Gottesman-Kitaev-Preskill Code

H. Yamasaki, K. Fukui, Y. Takeuchi, S. Tani, and M. Koashi

arXiv:2006.05416 [quant-ph], June 2020.

Scalability of flying photonic quantum systems in generating quantum entanglement offers a potential for implementing large-scale fault-tolerant quantum computation, especially by means of measurement-based quantum computation (MBQC). However, existing protocols for MBQC inevitably impose a polynomial overhead cost in implementing quantum computation due to geometrical constraints of entanglement structures used in the protocols, and the polynomial overhead potentially cancels out useful polynomial speedups in quantum computation. To implement quantum computation without this cancellation, we construct a protocol for photonic MBQC that achieves as low as poly-logarithmic overhead, by introducing an entanglement structure for low-overhead qubit permutation. Based on this protocol, we design a fault-tolerant photonic MBQC protocol that can be performed by experimentally tractable homodyne detection and Gaussian entangling operations combined with the Gottesman-Kitaev-Preskill (GKP) quantum error-correcting code, which we concatenate with the 7-qubit code. Our fault-tolerant protocol achieves the threshold 7.8 dB in terms of the squeezing level of the GKP code, outperforming 8.3 dB of the best existing protocol for fault-tolerant quantum computation with the GKP surface code. Thus, bridging a gap between theoretical progress on MBQC and photonic experiments towards implementing MBQC, our results open a new way towards realization of a large class of quantum speedups including those polynomial.

Efficiently Generating Ground States Is Hard for Postselected Quantum Computation

Y. Takeuchi, Y. Takahashi, and S. Tani

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Although quantum computing is expected to outperform universal classical computing, an unconditional proof of this assertion seems to be hard because an unconditional separation between BQP and BPP implies P≠PSPACE. Because of this, the quantum-computational-supremacy approach has been actively studied; it shows that if the output probability distributions from a family of quantum circuits can be efficiently simulated in classical polynomial time, then the polynomial hierarchy collapses to its second or third level. Since it is widely believed that the polynomial hierarchy does not collapse, this approach shows one kind of quantum advantage under a plausible assumption. On the other hand, the limitations of universal quantum computing are also actively studied. For example, it is believed to be impossible to generate ground states of any local Hamiltonians in quantum polynomial time. In this paper, we give evidence for this

impossibility by applying an argument used in the quantum-computational-supremacy approach. More precisely, we show that if ground states of any 3-local Hamiltonians can be approximately generated in quantum polynomial time with postselection, then the counting hierarchy collapses to its first level. Our evidence is superior to the existing findings in the sense that we reduce the impossibility to an unlikely relation between classical complexity classes. Furthermore, our argument can be used to give evidence that at least one 3-local Hamiltonian exists such that its ground state cannot be represented by a polynomial number of bits, which may be related to a gap between QMA and QCMA.

Polylog-overhead Fault-tolerant Measurement-based Quantum Computation by Homodyne Detection

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We have proposed a novel quantum state that can be used as a universal resource of measurement-based quantum computat ion (MBQC). By utilizing this state, we can perform quantum computing more efficiently than before. We have also analyzed the fault-tolerance of our MBQC method and confirmed that our method has a higher error-correcting threshold value than existing ones by numerical calculations.