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Electrical and Electronics Engineering

from Keio's Faculty of Science and Technology

Moving the world through
the power of electricity.

Takahiro Nozaki

Assistant Professor
Department of
System Design Engineering

In this issue, we introduce Assistant Professor Takahiro Nozaki of the Department of System Design Engineering who has set his sights on a society in which people and robots can live side by side.

Towards the realization of a society in which robots are there for you

Real-Haptics and power electronics could be the key

"Robot development" is gathering much attention as a solution to the shortage of labor resulting from a declining birthrate and an aging population. However, for robots and people to live together, there are many technical issues that need to be resolved. Assistant Professor Nozaki is tackling these issues through the Real-Haptics technology he inherited from his former teacher, Professor Kouhei Ohnishi, and technology he himself is developing in the field of power electronics.

Long-awaited arrival of a dexterous robot

Doraemon is a robotic cat who aids a boy with various gadgets from the future. Many people probably watched the animation as a child. Doraemon's birthday is September 3, 2112. Will such a robot be created in less than 100 years from now?

If you visit Assistant Professor Nozaki's web page on the Keio University Faculty of Science and Technology's Department of System Design Engineering website, a robot will appear at the top of the page (figure 1). The robot lifts up a plastic cup with one hand and pours water into it from a plastic bottle held in the other hand, following the actions of the operator in the operations system. I am astonished on seeing this, thinking "I've never seen anything like this!" Nozaki, who developed this robot, explains the reason why we are so amazed by this creation is because it is so dexterous. It doesn't crush the soft plastic cup, and even as the weight gradually increases when the water is poured, it doesn't drop it. Robots capable of such feats didn't exist until now.

Robots up to now crushed blueberries when they tried to pick one up. Nozaki describes this as being "clumsy," but it happens because without being able to sense that it has touched the blueberry, the robot can't adjust the amount of force it needs to apply. Although not robots, the reason you will be seriously injured if you come into contact with an escalator or train is because the escalator or train cannot sense that it has touched you.

The difficulty of acquiring a sense of touch

Robots that do the cleaning or guide people around facilities exist, but there are no robots that can perform caregiving duties. According to Nozaki, it is dangerous to use robots that can't sense that it has touched something, and therefore robots that touch humans have yet to be introduced into our daily lives. So, how can a robot be equipped with a sense of touch?

First, consider the characteristics of tactile sensation. Touch is one of the 5 senses humans use to sense the environment around them. The other 4 are vision, hearing, smell, and taste. While these 4 are all passive, touch is an active sense that is capable of moving objects and changing the world around us. Therefore, if there are expectations on robots to take on the duties that have been carried out by humans up to now, such as supplementing the shortage of labor due to a declining birthrate and an aging population, they must acquire a sense of touch and be capable of adjusting the amount of force to apply.

However, it is not easy to create actions that adjust applied force with touch. This is because actions have both a hard and soft side. The hard side of touch is the property of always wanting to go to the set location whatever happens, while the soft side is the property that makes adjustments when something is touched and a force is felt. For existing robots that do not directly touch human beings such as industrial robots, actions must be accurate, and emphasis has always been placed on the hard side. However, to create actions that adjust applied force with touch, both properties must be combined. Yet, from the beginning, these two properties conflict, making

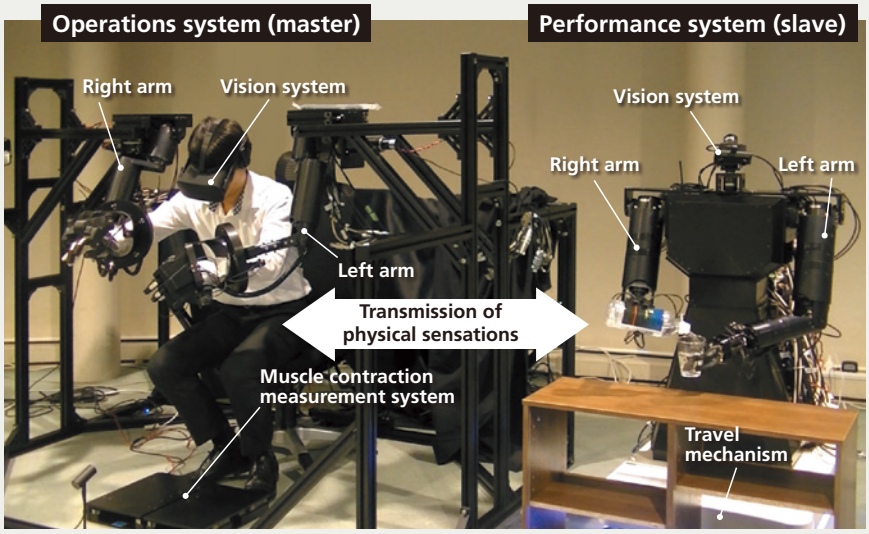


Fig.1 Robot with a sense of touch

Actions made on the operations system (master) are transmitted to the performance system (slave) to pour water into a cup. Tactile sensations on the performance system are transmitted to the human operator in the operations system allowing for the amount of applied force to hold a cup and to lift a plastic bottle to be adjusted.

the existence of the two together technologically difficult.

Nozaki's former teacher, Professor Kouhei Ohnishi, made it possible to combine these two properties through the development of Real-Haptics technology. By measuring the amount of motion required of the motor to move the robot, and collecting data on the additional force required to move the motor when it touches something, it can sense how hard the object it came into contact with is. This groundbreaking technology also led to the creation of the robot introduced on the web page at the beginning of this article.

Studying power electronics to develop better robots

It is not easy to move robots in the way you want. Even to bend the arm, the motor at the joint must gradually accelerate, reach a constant speed, and then decelerate and stop, and this process of accelerating and decelerating must be performed smoothly. Robots will only begin to move when each of these individual actions work in harmony.

Ultimately, the motors that move the robots are powered by electricity. Therefore, Nozaki began to think that it is important to know how to use electricity to develop better robots. In 2014, he went to study power electronics under Professor Atsuo Kawamura at Yokohama National University for a year. Since returning to Keio University, he has been developing power electronics technology that he believes will become useful in the future.

The field of power electronics, which looks at electricity supply sources and the conversion of electricity with the aim of efficiently transmitting electrical power to users, has been studied for a long time.

Once electrical power became available, it was used to run motors, and then motor drives were created. Next, accurate motor rotations and the running of several motors simultaneously were pursued, leading to the birth of fields such as control engineering and robotics. In this way, new academic fields and technologies came into existence one after another in response to the needs of society. According to Nozaki, at the forefront of this is Real-Haptics technology (figure 2).

For a single robot to function, a wide range of academic fields including power electronics, thermal engineering, motor drive, control engineering, motion control, robotics, mechanical engineering, human factors, and signal processing must come together. The complexity and instability of society has increased considerably, making it difficult to deal with all of the problems that are seen today through traditional academic fields alone. This can be resolved through a systematic design approach, which can be learned at the Department of System Design Engineering.

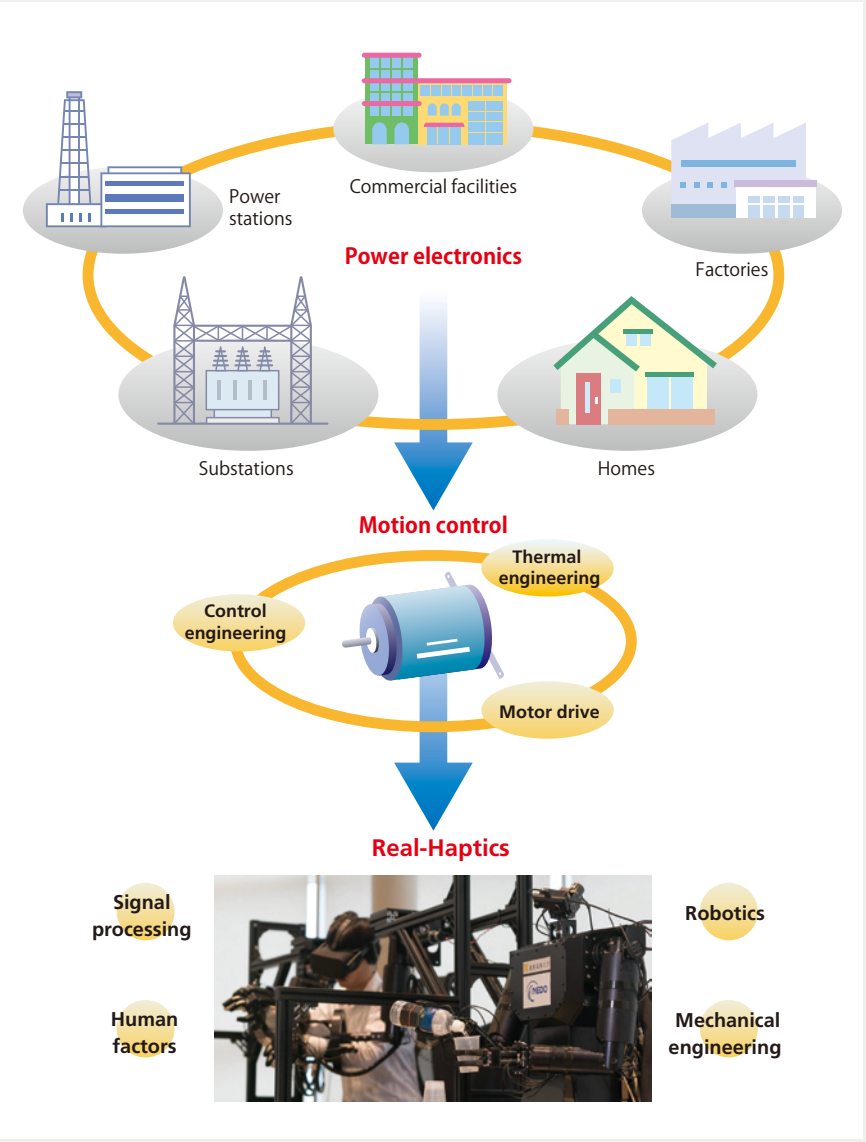


Fig.2: Power electronics and robots

New academic fields and technologies were created one after another in response to the needs of society. Achievements in these have been integrated to develop robots.

A future taking full advantage of touch and motion

Nozaki wants to continue to work hard in his research revolving around the two fields of "Real-Haptics," which he inherited from his teacher, and "power electronics," which he is advancing as a source of new strength in robotics. At the same time, however, he is working on product development with many industries to commercialize Real-Haptic technology. Currently, he is working with an airline to develop a system that enables people to experience fishing far away from the actual location without having to go there in person, while with a manufacturer of fruit sorting machinery, he is developing a fruit and vegetable sorting machine that will remove spoiled fruits without crushing them.

Just like making video and audio recordings to save and transmit what we see and hear, in the future, with the spread of Real-Haptics technology, it may become possible to save and transmit various movements and tactile sensations. What will the future be like then? Nozaki says that just like you wouldn't prepare a boat and bring in actors and the director to watch the movie "Titanic," you won't have to wake up in the morning and make an omelet by yourself anymore. You will simply download the motion data to make an omelet from the internet and have a robot do it for you.

It looks like this technology will bring us a future beyond our imagination.

(Interview and text writer : Akiko Ikeda)

Assistant Professor Takahiro Nozaki

It is because no one knows the answer that in research you can confront and find yourself

If he had to choose between the "North Wind" and the "Sun" in Aesop's Fables, Nozaki says that he is like the North Wind toward his students. He basically leaves them to carry out research on their own initiative because he believes that doing research and "having to really think about things" is an important experience for students who haven't needed to do this before in order for them to confront and find themselves. What shaped his way of thinking can be attributed to his parents who raised an independently-minded child and a former teacher who prized individuality.

Did you like robots since you were a child?

I often get asked this question. I feel that people expect me to say that I loved robots or that I spent a lot of time in Akihabara, but this wasn't the case for me at all. But I loved Doraemon, and there is a picture of me looking very happy surrounded by Doraemon picture books (photo).

At any rate, I disliked teachers, and when I was in junior high and high school I would sometimes play truant. My mum and dad had a hands-off approach to parenting, so I didn't really get in trouble. In fact, when I told them that I wanted to take an exam to get into junior high school because my friends were doing so, they told me not to bother.

I heard you intentionally gave up going to university before getting into Keio.

I was accepted into a university while I was in high school, but taking the university entrance exams got me thinking more about my future. I felt that I had to think properly about what I wanted to do and what will become necessary from now on, and to figure this out, I decided not to enter university immediately after high school and took a year out. It was during this time that I realized that I wanted to study robotics. To find out which universities had a strong control engineering program, a key area when developing robots, I read a book and found out that Keio was first in Japan and ranked in the top 5 in the world. This was why I chose Keio.

However, once I entered university, I completely forgot about this, joined the tennis club, and enjoyed my student life. I went drinking with my friends and I married a girl who joined the tennis club when I was in my second year after dating her for about 10 years.

You hoped to join Professor Kouhei Ohnishi's laboratory when you had to choose a laboratory, didn't you?

When we had to choose a laboratory to join, I remembered that I wanted to study at Keio to learn about robotics and applied to join Professor Ohnishi's laboratory. I wrote my background and reasons for wanting to join his laboratory on an A4 sheet and went for my interview, and when Professor Ohnishi saw that I was from Nakano, he asked if I knew Nakano Ward Momozono No. 2 Elementary School. It turns out that we went to the same elementary school. After that, I talked a lot about our school. I was sure I wouldn't get in, but surprisingly, he accepted me.

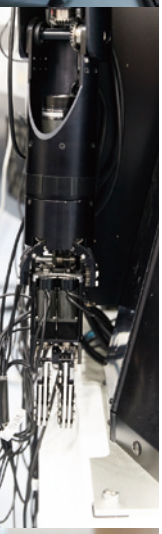
Just before he left the classroom after the interview, Professor Ohnishi asked me if I had drawn lines before writing the document. To write documents neatly, I first draw lines on A4 sheets with a pencil, and after I finish writing, I erase the lines. Even though we didn't talk about my research at all during the interview, he had read through my reasons for wanting to join his laboratory, and I realized from this that he was able to feel my motivation for applying. I was deeply moved.

What kind of laboratory was it?

He was like the North Wind in "The North Wind and Sun." By this, I mean that in contrast to those teachers who really take care of their students, Professor Ohnishi was very hands off. It seems that he took this approach out of respect for the students' individuality. However, he gave us a lot of encouragement.

He once asked us to imagine seeds planted right in front of us. Then he asked what we think should be done to help the sprouts grow once they appear. He said that if you try to make the sprouts bigger by recklessly tugging at them, you will pull them up and they will die. For the sprouts to grow, they need sunlight, and you need to give them plenty of water and fertilizer. He said that if a teacher really wants the students to grow, the most important thing the teacher can do is to provide a suitable environment for them.

He talked about "youth worries" too. He said that we may now be preoccupied with someone we like or our grades falling, but these are things that don't matter to other people, and are what are called "youth worries." According to him, real worries are those you have for others. However, he went on to say that only those who have thoroughly experienced such worries in their youth will be able to cope when faced with real worries, and that we should therefore embrace the worries of our adolescence. Thanks to these words, I have been to able overcome my worries many times since then.



What kind of teacher are you?

I also basically have a hands-off approach because I thought Professor Ohnishi was cool. However, there are students who develop more when given attention, so I try to adjust to the students' needs.

I feel that students these days haven't really thought about things for themselves. It can't be helped because for high school tests and entrance exams, they only need to reproduce the answers they have memorized. But I feel they are still living according to the values that are held by the adults around them. Research is one way to break this habit. While studying new things without a single answer through research, students have to confront and find themselves. I think that it's really amazing watching them grow up.

You seem to have had a lot of experiences, such as taking a post at Yokohama National University and setting up venture companies.

I wanted to study power electronics, so I got a post at Yokohama National University for a year. Professor Ohnishi preached that it only takes 3 seconds for the future to change, so opportunities must never be missed. These words gave me a push at that time too. Since coming back to Keio, I have been busy every day with supervising students, as well as putting my research outcomes to practical use and developing products with companies. In particular, there is a big gap between writing papers, the most important thing when doing research at university, and developing products that must make a profit, and I am realizing how hard it is to fill this gap with each passing day. Creating something meaningful for the world while writing papers and producing results is not easy. I always think that I need to remain strong to ensure I don't cut corners in either task.

What kind of place is Keio University for you?

In addition to students who entered the university through the general entrance examination, there are those who advanced from the affiliated high schools and those who came back to Japan after spending some time abroad, making Keio a university with a rich diversity of students who each have distinct personalities and academic abilities. Watching the students, I can see them mutually influencing one another while growing up. If they have a friend who is good at English, they try to improve their English as well, or if they see a well-dressed student, they also pay greater attention to their appearance.

My son was born in February this year. His name is Yoshihiro, written using the "gi" kanji character in Keio Gijuku, and the kanji for "hiro" from my own name. You may wonder how much I'm in love with Keio, but it is where I, who hated teachers, got my PhD and became a lecturer, which I never imagined I would be, so to me Keio is a place I cherish because it changed my life. I don't want to go home before the students, but sometimes I go home early to give my child a bath. He's very cute. The first stuffed toy I got for him was of course Doraemon. But I'm not trying to influence him to live the life I chose for myself.

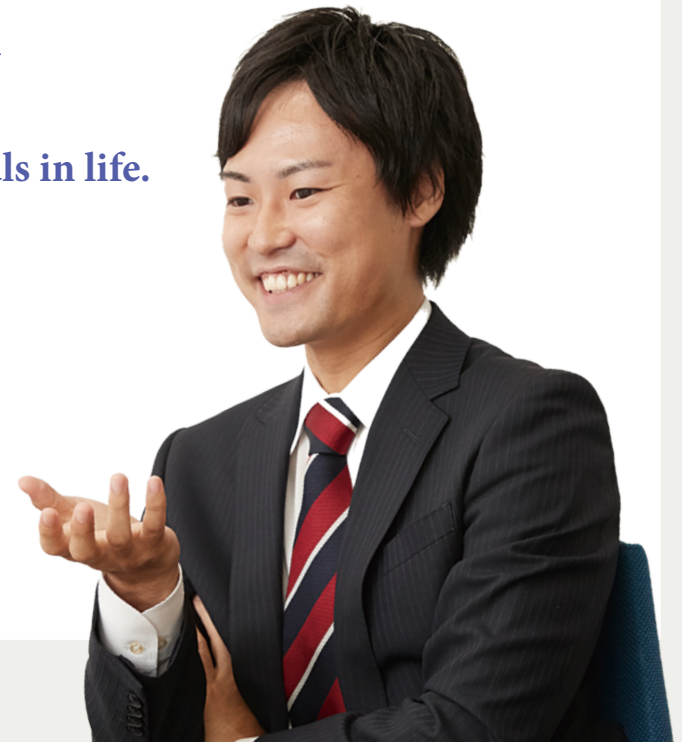
◎ Some words from students . . . ◎

- At the interview, I was asked about my determination, to which I replied I will do my best. I'm interested in robots, and I also think this field will develop more in the future. (4th-year undergraduate student)
- I'm very satisfied because I'm allowed to do what I want to do. He's very strict when it comes to doing research, but he is also someone who pushes me. If he's not around, he is often in America or somewhere overseas. (1st-year master's student)
- He's so passionate about spreading robotic technology that it's frightening. At his laboratory, you have to find on your own a research theme that should be looked at but no one is doing yet. I was once told that a theme I chose isn't research. There were times when I was anxious, but carrying out the whole research process on my own has given me a lot of confidence. (2nd-year master's student)

(Interview and text writer : Akiko Ikeda)

For the full text of this interview
http://www.st.keio.ac.jp/kyurizukai

Keio University is the place where I decided to continue doing research and become a teacher. I also want students to find their goals in life.



Takahiro Nozaki

Assistant Professor at the Department of System Design Engineering, Keio University Faculty of Science and Technology. PhD (engineering). Specializes in electrical and electronic engineering, control engineering, and robotics. Joined the Faculty of Engineering at the Yokohama National University as a research faculty member after finishing the doctoral program at the School of Integrated Design Engineering, Keio University Graduate School of Science and Technology in 2014. Became a Research Associate (non-tenured) at the Department of System Design Engineering, Keio University Faculty of Science and Technology in 2015, and has had his current position since 2018.

My first international conference

Stopped in Slovenia while I was on my way to a conference in Sarajevo, Bosnia and Herzegovina. This photo was taken in front of the Triple Bridge, the symbol of Ljubljana, the capital city of Slovenia. I was shocked by how big the world is, instantly broadening my horizons.

6-laboratory joint study camp

At the 6-laboratory joint study camp held every year at Tateshina Lodge. We work hard from morning to night and have a lot of fun during the breaks.

Photo with my eldest son

His name is Yoshihiro, written using the "gi" kanji character in Keio Gijuku, and the kanji for "hiro" from my own name. He is very cute!!

Trip to Germany while I was a master's student

This photo was taken in front of the Frauenkirche (Cathedral Church of Our Lady) in Munich. My friend who also enrolled in the doctoral program afterwards is in the photograph with me.

Takahiro Nozaki history

Trip to Hokkaido

A trip to Hokkaido to be at the wedding of two tennis club teammates. We played a game of tennis for the first time in many years while recollecting our student days.

Closing group photo

At the 8-university power electronics study session held every fall. After working hard, we all get together for a closing group photo!

When I was a research associate

A visit to Italy with my students. This photo was taken in front of the duomo in Florence (Cathedral of Santa Maria del Fiore). At the far left is Associate Professor Motoi of Kobe University.

Table tennis at Tateshina Lodge

If the courts are available, we can also play tennis, basketball, and futsal. The main purpose of the trip is to study so we don't have a lot of free time, but there were years when we got too excited and half of our luggage was sports equipment...

At a hot spring after a seminar

We went to a hot spring in Minatomirai, Yokohama (Manyo Club) after a seminar. Everyone is having a good time drinking beer after bathing. However, with so much energy, couldn't we have done better at the presentations? (laughing)

私の本棚
My favorite books

Contact with the external environment and towards robust motion control

Practical control engineering

My academic advisor while I was a student, Professor Kouhei Ohnishi, wrote this book. The greatest highlight of this book is its coverage of the construction method of a robust control system based on observer theory, but it also covers methods to identify parameters as well as modern control, making this a book I highly recommend. This book, together with "Basics of control engineering" of the same series, are necessary for all control engineers to read.

Creating force with electricity

Electromechanical Dynamics I

This is a textbook that was used as part of the core curriculum at the Massachusetts Institute of Technology. It is made up of 3 volumes: Electromechanical Dynamics Part I: Discrete Systems; Electromechanical Dynamics Part II: Fields, Forces, and Motion; and Electromechanical Dynamics Part III: Elastic and Fluid Media. It is renowned as being an excellent reference book.

Creating rotation

Theory of electric motors and generators

This book is used at my laboratory study session held every spring to teach basic theory. In addition to explanations and diagrams that can be easily understood, videos can be viewed on the internet, making this book popular among students.

Controlling rotation

Modern Control Engineering Fifth Edition

I read this book when I joined a laboratory as a student to learn the basics of control engineering. This book is written in English so it may feel challenging to beginners, but you will get to know basic technical terms in English and you will learn a lot from it.

Transmitting electricity

Semiconductor Power Electronics

Professor Atsuo Kawamura of Yokohama National University who gave me a lot of assistance while I was working there translated this book. He has also written other books such as "Introduction to power electronics: from the basics to its practical use (Corona Publishing Co., Ltd.)" and "Modern power electronics (Suri Kogakusha)" from which you can learn a lot. I recommend these books.

These are not technical books, but...

I also like "I'm not academically able" (Amy Yamada) and "How will you live?" (Genzaburo Yoshino). These books make me realize that I shouldn't be brainwashed into a stereotypical way of thinking.

Overlooking the way things are as they are, without being mindful of them, is no different to how horses act

Takahiro Nozaki

The official name of "Kyurizukai," used as the name of this magazine, is "Kinmo Kyurizukai." "Kinmo Kyurizukai" is the name of a book by Yukichi Fukuzawa published in 1868, the first scientific reading material in Japan, and the above title is a line from this book. "Kyuri" is what we now call physics, and "kinmo" means to explain things clearly to children or beginners. From the perspective of teachers who have dedicated their whole lives to learning and research, I too am still basically a novice and therefore I cannot act too self-importantly. However, if I were to say one thing to students, it would be that they should live their lives to the full.

Power electronics is the field that studies the conversion and transmission of electricity. Through electrical power, motors can be rotated, and by skillfully controlling this and applying it in the external environment, changes can be made in the real world. Of course, if nothing is done, nothing will change.

I think things are the same in life. If you eagerly and enthusiastically do your best, focusing intently on your studies and research, I think you will be able to make gradual changes in the real world. If you don't think about anything, don't do anything, and just waste time, nothing will change. Although it may be extreme to say so, if nothing ever changes, it is perhaps not very different from not living at all.

Incidentally, the motto of my laboratory is to "make memories at university and leave footprints in the world." I sincerely hope that students fully enjoy their university life and time at their research laboratories, and leave proof that they have enjoyed themselves and lived life to the full. I am convinced that their energy will be the source of change in the world. Let's transform the world together with a spirit of jiga sakko*. Make memories at university! Leave footprints in the world!

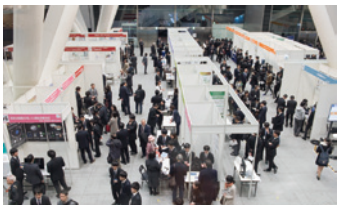
*Jiga sakko (creating history to define the future; also read "ware yori inishie wo nasu") means to create something new yourself that can become common practice or a model case, without being trapped by what has previously been done. These words were also said by Yukichi Fukuzawa, and shows the determination of Keio students in the early days of Keio University who wished to adopt Western culture at an early stage to contribute to the modernization of Japan. This, together with "dokuritsu jison (independence and self-respect)," constitutes the founding philosophy of Keio University.

Science and Technology **Information**

KEIO TECHNO-MALL 2018, 19th Keio Science and Technology Exhibition "beyond imagination: encouraging advances to the future"

KEIO TECHNO-MALL (Keio Science and Technology Exhibition) is an event that showcases the research results of Keio University's Faculty and Graduate School of Science and Technology, and serves as a forum to encounter future collaboration partners in government, industry, and academia for joint research, technology transfer, and more. With over 100 exhibits centered around demonstrations on display, and short presentations and round-table discussions by researchers, it is the biggest event of its kind at the university with many people from industry, the public sector, and other educational institutions visiting every year.

Date and time: December 14, 2018 (Fri.) 10:00–18:00
Venue: Tokyo International Forum, B2F (Hall E2)
Content: An attractive exhibition that emphasizes demonstrations and displays of actual products is planned
Admission is free * Advance registration is not required for any event.
Details: www.kll.keio.ac.jp/ktm/



〈**Special interview and talks (planned)**〉

1. Special interview
   Guest: Katsuo Fukuzawa (Drama and Movie Director, Drama Production Department, TV Production Division, Tokyo Broadcasting System Television, Inc.)
2. Round-table session I
   Guest: Shigeki Ishikawa (R&D Academic Advocate, IBM Japan)
   Masaya Mori (Executive Officer, Rakuten, Inc.; Global Head, Rakuten Institute of Technology; and Director, Rakuten Life Insurance Technology Laboratory)
   Ryo Shimizu (President, GHELIA Co., Ltd.)
3. Round-table session II
   Guest: Hiromichi Shinohara (Chairman of the Board, Nippon Telegraph and Telephone Corporation)
   Tomomi Nakamura (Representative Director, President and CEO, Subaru Corporation)

Editor's postscript

This year marks the 10th anniversary since the publication of this magazine began. On this first issue of the 10th year, we feature Assistant Professor Nozaki, who was still only a university student a decade ago. Nozaki speaks of his dislike for teachers when he was a child and how he never expected to become one himself. Yet in his laboratory, he is approached by many students and has the demeanor of an educator. Although only intending to interview one student about Nozaki, in the end, I heard stories from almost ten members of his laboratory. It was evident from all of them that Nozaki is a teacher who is beloved by his students. (Izumi Hagiwara)

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