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新版

# 窮理図解

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[http://www.st.keio.ac.jp/kyurizukai/top\\_eng.html](http://www.st.keio.ac.jp/kyurizukai/top_eng.html)

## Ubiquitous Sensing

from Keio's Faculty of  
Science and Technology

Challenging the visualization of  
"thought and thinking"

– Seeing, observing and examining brain waves  
(electroencephalogram:EEG)

Yasue  
Mitsukura

Associate Professor  
Department of System  
Design Engineering



# Signal processing is being used everywhere in modern society

The future that analysis of ubiquitous Bio-Signals will open

Brain-computer interfaces can measure our physical/mental states, such as pleasure/pain, stress and sleepiness by measuring and analyzing brain waves (electroencephalogram:EEG). Avatar systems can detect movements of our face and changes in facial expression using a compact web camera and project them instantaneously onto an avatar on the monitor screen . . . explained Associate Professor Mitsukura who focuses on the development of these innovative systems.

## Measuring our physical/ mental states in an instant from a combination of brain wave frequencies

“By simply wearing this device on your forehead, it is possible to measure your pleasure/pain, likes/dislikes, stress, sleepiness, or degree of your concentration or interest. It may be safe to say that this one is the most simplified and easiest-to-use device of its kind available today. Of course, its performance capability is never outdone by its category.” Saying so, Dr. Mitsukura showed a headband-like electroencephalograph (EEG). The EEG is designed to send information from the headband-like sensor to a smart phone and instantaneously displays the measurement result on the smart phone screen.

If you are feeling stress, for example, the white face icon on the screen will turn blue and the degree of stress will be shown as a percentage. Likewise, if you start up an application for the



**Fig.1 Detection of sleepiness by means of brain wave analysis**

Degree of sleepiness can be detected online by easily obtaining brain waves and analyzing them instantaneously.

state of concentration or sleepiness, as a test subject you will be able to clearly see your constantly changing state of concentration or sleepiness in real time.

Raw data obtained is also displayed on the screen simultaneously. The waveforms shown in line graphs represent frequency bands, such as  $\alpha$ ,  $\beta$  and  $\theta$  waves, that are languages commonly used to indicate brain waves. According to Dr. Mitsukura, it is possible to measure a subject's state by analyzing a combination of his/her brain wave frequencies.

She continues, “You wear a sensor on your forehead to measure the state of what is called the FPI, the area of the brain in the left-side frontal lobe that governs emotions and sensitivity. At this time very small voltages in the microvolt order are measured. Types of brain waves can be known by converting these voltages into frequencies. Brain wave frequencies are limited to the 1~30Hz range. One's physical/mental states can be known from combinations of pieces of such slight pieces of information.”

Take the sense of touch, for example. You can judge that you “like” an object if the value of a combination of  $\bigcirc$ Hz and  $\times$ Hz is large, while you “dislike” the object if the value of a combination of  $\triangle$  Hz and  $\diamond$ Hz is small. Finding out such rules and allowing the particular state to be identified instantaneously via the optimization method are the greatest features of this system.

In addition to the EEG (electroencephalograph), brain-measuring instruments available today include the f-MRI (functional magnetic resonance imaging) and NIRS (near-infrared spectroscopy). But each of these systems has its own measurement target. To examine the state of the brain, the f-MRI targets brain blood flow while the NIRS is dedicated to

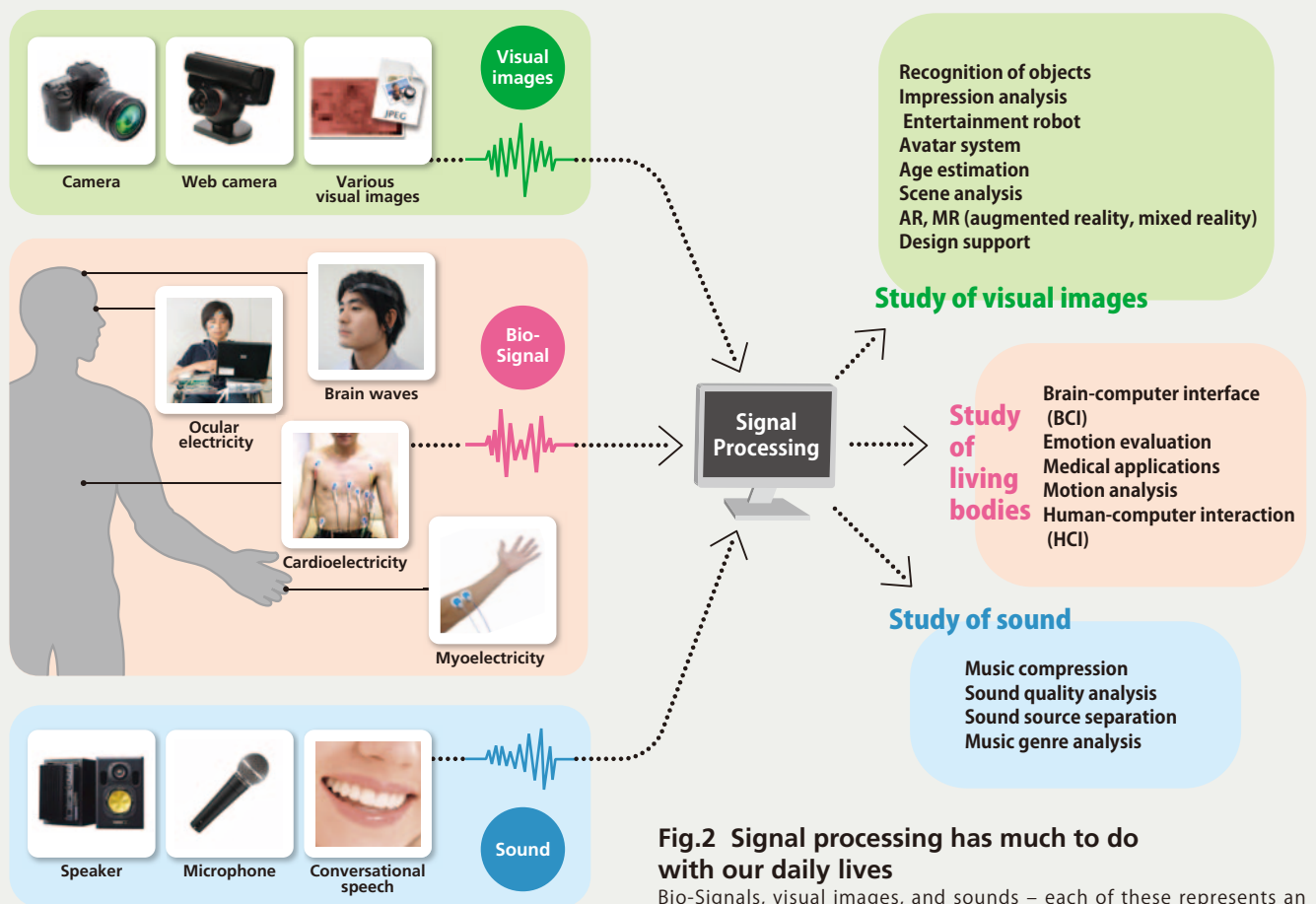
brain blood oxygen level. Here, we have to remember that brain waves quickly respond to any psychological change that occurs. As such, real-time measurement is fit for brain wave measurement.

Furthermore, it has been a major drawback with conventional brain wave measuring instruments that accurate measurement is not possible because the subject must have several electrodes adhered to his/her scalp, which is time-consuming while wearing the instrument itself is stressful. But Dr. Mitsukura's device is easy to wear and enables what a person is feeling to be measured accurately. In fact, the device already began to be used as a marketing research tool to determine the degree of interest in sound, taste, new products and so on.

## Obtaining accurate measurement results by formulation of brain waveforms

However, is it really possible to obtain accurate measurement results using such a simple device? No problem. The signal processing technology, Associate Professor Mitsukura's field of expertise, enables measurement by the device well comparable in accuracy to other types of measuring instruments.

She says, “Most of simplified EEGs adopted in games operate by acquiring myoelectric signals that are generated, say, when you move your eyelids, and they do not deserve being called EEGs. A lot of noises are mixed into brain waves, most of which are myoelectric noises, making it very difficult to selectively pick out pure brain waves. In fact, myoelectric noises are not eliminated with most of the simplified instruments available on the market today. Our device, therefore, is designed to eliminate such noises



**Fig.2 Signal processing has much to do with our daily lives**

Bio-Signals, visual images, and sounds – each of these represents an aggregate of signals on a certain scale. Signal processing is a process of grasping the characteristics of these signals, classifying them into patterns, and imparting a meaning to each pattern. When it comes to living bodies, we generally deal with signals ranging in voltage from micro-volts to milli-volts; for visual images, signals ranging in RGB value from 0 to 255; and for sounds, signals ranging from 20Hz to 20kHz. Studies of analyzing these signals have much to do with a wide variety of products found in our daily lives.

instantaneously and enable accurate measurements.”

In her early career, Dr. Mitsukura had long engaged in the study of formulating behavior of industrial plants and equipment for years. She says that the experiences she had nurtured through the work of formulating such behavior proved to be a great asset for the development of the current system.

“The impetus for my taking up the development of this system was an encounter with an ALS (amyotrophic lateral sclerosis) patient. As the disease



**Fig.3 An online avatar system allows you to transform into a popular avatar in an instant**

Only if you have a common inexpensive camera (shown in photo is a camera for Playstation) and a PC, you can analyze movements and expressions of your face in an instant and express them using an avatar.

progresses, ALS patients eventually become unable to communicate with the outside world except by the movement of their eyeballs. When the patient who used our EEG system became able to express his Yes/No, his family members were very pleased, which fueled my motivation. I was determined to accelerate this research project by all means. In the future, I aim to make this device an even more simplified and easy-to-use system – one that will allow users to express what they are thinking directly into letters,” she remarks.

**An avatar system that can instantaneously follow the movement of one’s face**

The Mitsukura lab has also developed another signal processing-based system. It is an innovative avatar system. With this system, a web camera attached to a PC recognizes movements of a person’s face, allowing an avatar on the PC screen to follow the movements in real time.

“We took up this research project with the aim of tracking facial movements and expressions within 0.1 second. The

key behind the success of this system was that we enhanced computation speed by narrowing down tracking points – both ends of the eyes and both ends of the mouth – to facilitate instantaneous reactions,” she explains.

As the avatar for this system, she used Hatsune Miku and uploaded it to the YouTube video-sharing website. This attempt was rewarded with over three million views. As a result, she is flooded with numerous inquiries from interested companies regarding its use for animations, promotional events and CMs, among others.

She adds “Also, we are handling the development of various other systems, such as a system for scrolling the PC screen with a whistle and a technology for moving a wheelchair using myoelectricity.”

All of these innovative systems are based on signal processing technology. In conclusion, Ms. Mitsukura vigorously mentioned that she would like to continue to develop systems that could contribute to society by leveraging signal processing technology.

(Reporter & text writer: Madoka Tainaka)



## Finding pleasant things and doing my best whether in research or pleasure

**Dr. Mitsukura is tackling the development of innovative systems based on signal processing technology. She is a short sleeper, but never cuts corners whether it is research or pleasure. The source of her restless energy seems to come from her forward-looking attitude of finding pleasant things and thoroughly pursuing them.**

### You were born in Nara Prefecture, and then moved to Matsue City in Shimane Prefecture where you entered a scientific high school. Is that right?

That's correct. Although I had moved from one workplace to another to date, I have at last found a place in which I can settle in peace. I chose the scientific course as a high school student presumably because I was raised in a family where my father is a man of science and mother from the medical field. In fact, bookshelves at my home were filled with books on mathematics, physics and medicine – no picture books and the like for children. Even now the scene of my father studiously reading such books on holidays is printed on my memory. I still remember the day when I dropped and broke a piece of glassware. At the time my father explained to his small daughter earnestly and in detail about “why it can be broken.” His explanation was so interesting that I broke various other things merely for the sake of interest – my mother scolded me. Raised in such a family atmosphere, it was natural that I chose a scientific high school and then specialized in electric/electronic studies at a university.

I moved from one place to another to study – at Okayama Prefectural University until I completed my master's course, earned a doctor's degree at Tokushima University, studied at the University of Tokyo's Graduate School of Medicine, worked at Okayama University and Tokyo University of Agriculture and Technology, and finally moved to Keio University in 2011.

### When did you make up your mind to choose a researcher career?

When I was a senior, I had an opportunity to participate in an international academic conference on telecommunications, where I won the best paper prize and the best presentation prize. In relation to the paper I would read at the conference, I had run into a great wall (though it's not too serious a problem as I look back at it today) and had to sit up sleepless for several days in a row. However, the moment I won the prizes, all the hardships I had experienced were blown away and replaced with utmost delight, which I still remember vividly. Through this experience, I learned the importance of dedicated effort and willpower necessary for solutions when I come face to face with a problem.

Later, an encounter with Professor Norio Akamatsu during my service with Tokushima University marked an important turning point for my career as a researcher. When we were bothered with noise from a nearby construction site, I spoke to Dr. Akamatsu, saying, “If we produce sound of opposite phase, the noise outside disappears, doesn't it?” This is nothing special, but Dr. Akamatsu praised me as being always conscious of my own research in

relation to daily matters. He even guaranteed that by maintaining such an attitude I would be able to grow into a full-fledged researcher. This word of encouragement has supported me as a researcher ever since. As I continued the work of converting sounds and visual images into frequencies and formulating them day after day, I found myself capable of connecting various phenomena with frequencies, and by merely hearing sounds or seeing images I naturally became able to make out what frequency components are contained there. Now everything around me appears as a frequency or a formula – almost an occupational hazard you might say.

Thanks to the advice given by Dr. Akamatsu, I came to engage in research into brain waves. Back in those days, I was totally absorbed in matters related to frequencies. In my doctor's course, I focused on research into frequency analysis of facial visual images. This project aimed to distinguish individuals by formulating visual images of faces. Individual faces can be distinguished by comparing formulas . . . Don't you think it's interesting? After all, I was able to earn a doctor's degree in a year and a half.

### What was your life as a researcher like?

Day after day, I went to the lab and devoted myself to research work until 2:00 a.m. As a short sleeper by nature, I could refresh myself after five hours of sleep, so such a lifestyle was not hard at all. What's more, it was my daily routine to enjoy jogging with Dr. Akamatsu in the early evening. Thanks to that habit, I enjoy



## Eating well, learning well, playing well, being moved well by good things, laughing well, and shedding tears occasionally . . .

marathons even today. Every year I take part in major marathon races like the Shonan International Marathon.

### You are very powerful. What does your energy come from?

When I have to make any decision, I make it a rule to judge by likes/dislikes. Of course I choose what I like, so there is no room for stress to accumulate, I believe. Whenever I find something interesting, I challenge it single-mindedly and with all my energy. So I had no anxiety at all when I decided to move from Okayama to Tokyo.

To tell the truth, I am the younger sister of identical twins. My elder sister, Hiroe, passed away years ago. The loss of my sister largely changed my way of life. I made up my mind to live a double life including that of my sister – appreciating both pleasures and pains.

Therefore, it is my rule to do research work with all my might and enjoy pleasures with all my might as well. Unless my work schedule is too tight or I have a business trip to take, I set aside Sundays as free days to enjoy myself to the fullest.

For example, my holiday schedule for this month is already full (*laughter*). No matter how much I may enjoy a holiday, I never carry fatigue to the following day. It's my principle.

Enjoying a lot of delicious food is another pleasure although I specialize in eating (*laughter*). Eating well, learning well, playing well, being moved well by good things, laughing well, and shedding tears occasionally . . . This is my lifestyle.

### But we are afraid that going at such a breakneck speed might make you tired. What do you think?

Maybe running keeps me in good shape. I'm confident in my stamina. On Sundays, I try to run as much as I can. Whenever I take official overseas trips, I bring my jogging shoes with me and run around town so that I can feel the atmosphere of the town firsthand. Running erases the fatigue of journey from Japan to that country. I often invite my students to join in running while also advising them to learn well and play well like myself.

### How do you like your research life at Keio University?

The atmosphere of Keio University is truly unrestricted and there are many researchers of colorful characters, so I feel at home here and am enjoying an unrestricted research life. It's also wonderful that Keio has a culture of caring for each and every student attentively. This is why I like Keio. In years ahead as in the past, I'd like to continue to give full play to my creative imagination – based on signal processing technology – and energetically pursue research themes that will benefit society.



## Yasue Mitsukura

Ms. Mitsukura pursues research related to multimedia signal processing and Bio-Signal analysis, using Bio-Signal processing, brain wave (electroencephalogram:EEG) analysis, visual image processing, semantic analysis of visual images and impression analysis as keywords. In 1999, she became a research assistant for Tokushima University Department of Information Science and Intelligent Systems; in 2002, she became a full-time lecturer for Okayama University Information Education Course; in 2005, she became an associate professor for Tokyo University of Agriculture and Technology in 2007; and in 2011 she moved to Keio University assuming the current position as an associate professor for the Faculty of Science and Technology.

### ◎ Just a word from a student ◎

● Dr. Mitsukura is very stoic when it comes to research. But even when I come out with an unexpected idea, she generously allows me to go ahead, saying, “Why don't you try it?” And she is kind enough to follow up my endeavor with proper advice, which is very nice. All of us at the lab are following Dr. Mitsukura's example – tackling both research work and pleasure with all our might.

(Reporter & text writer: Madoka Tainaka)

For the full text of this interview

<http://www.st.keio.ac.jp/kyurizukai>



**Mitsukura lab participates in an academic conference**

A group of ten Mitsukura lab members, seniors and graduate students, visited Aomori Prefecture to participate in an academic conference, where all of them made presentations. For the seniors, it was the first academic conference and everyone said their hearts pounded when reading papers.



**Pet dogs at my home**

Initially I intended to keep only one pet dog but the number increased to four before I knew it.

**A tomboyish student from abroad**

An overseas student from France joined Mitsukura lab. She took part in a study camp jointly organized by the Hamada and Mitsukura labs.



**Upon completion of the lab's interim paper presentation**

The Mitsukura lab holds several major get-togethers annually. Our policy is to learn well and enjoy get-togethers as well.



## Dr. Mitsukura and Mitsukura lab ON and OFF hours

Shown here are some aspects of the Mitsukura lab that are usually not visible from the outside.

**An academic meeting in Hawaii**

In March, we visited Hawaii to participate in an academic conference. Photo shows a scene from the farewell party, where Ms. Mitsukura was delighted like a mother when her student won a prize.



**Summer camp**

Our annual summer camp is held jointly with the Hamada lab. Nighttime enjoyment seems never-ending.



**Mitsukura lab also active on snowy slopes**

"I'll challenge this straight downhill run!" . . . Won't you join us after you've completed your graduation or master's thesis?



# 私の 本棚

My favorite books



## ● The Boundaries of Consciousness: Neurobiology and Neuropathology

This book approaches the question of "What is consciousness?" from the perspectives of science, medicine and engineering. This book is especially valuable for those who study the brain as it allows them to learn comprehensively from the fundamentals of cerebral functions through the world of pathology. It consists of as many as 40 topics, each completed in its own. This book is also interesting as read itself because it deals with intriguing topics like near-death experiences. Given technical terms from different fields, one who has read through this volume will become able to understand terminology used when approaching the brain from science, medicine and engineering fields.

## ● EEG Signal Processing

This technical book elaborately explains EEG signal processing. It introduces virtually all techniques from noise rejection through analysis of brain wave signals. This book is a must for students who are assigned to Mitsukura lab's biosignal group.

## ● Pattern Recognition and Machine Learning (Volumes I & II – Japanese version)

The author of this book is Christopher M. Bishop. As far as I know, researchers from a wide range of academic fields widely use this book for study meets and other occasions. I hear that motivated young-generation researchers (including doctoral students) especially value this book in their weekly study meets. If you use this book together with its original in English, you will be able to learn delicate nuances only available with English. From the perspective based on the Bayesian (decision-making) theory, it explains the theory and application of machine learning and pattern recognition. I guarantee you will acquire a lot of knowledge from this book.

## ● Momo (Japanese version)

This book appears to be a soft-touch writing for children. However, as an adult reader you will find it a unique and strange book because the message it conveys differs depending on how you interpret it. In fact, it is a book on one's values in life. It poses questions, such as: "What values can make you happy?" and "Are you really happy with the values you are now holding?"

## ● Senses/Emotions and Robots (in Japanese)

In this book, experts from various fields explain, in an easy-to-understand way, about senses, emotions and sensitivity from their respective specialty viewpoints. As science and engineering-oriented students, we are prone to approach these subjects from our particular perspective. However, this book sheds light on different approaches from wide-ranging fields, such as psychology, art, dentistry and medicine. For the purpose of application to computers and robots, the book also introduces diverse examples of application (of senses, emotions and sensitivity) to system design and design engineering. I recommend this very intriguing book to students who are giving serious thought to taking up this research field.

## ● Mind and Brain

The mind is an information processing system in which various elementary functions, such as emotion, sociality, memory and thinking, interact with each other. This book explains the mind in an easy-to-understand way and elaborately. Unlike other books of this kind, however, it introduces theories from wide-ranging academic domains as well as the author's own knowledge, which was exciting enough to arouse my intellectual curiosity as I read it. The author is, of course, Mr. Yuichi Anzai, a leading specialist in cognitive science and the former president of Keio University.

## Wonders of brain – the home of our mind

Yasue Mitsukura

It is said that of all animals, only humans have cognizance. Recently some insist that animals like dogs can laugh or feel sorrow, but it is not scientifically proven yet. I have four dogs at my home. To me they sometimes appear to be laughing or feeling sad, but I know it's nothing but my subjective impression or an interpretation for my own convenience.

Incidentally, do you know where our mind is? In our heart? No, it's in our brain. If you put it this way, the human brain is a very wonderful organ, isn't it? The brain feels all emotions and expertly processes an enormous amount of information captured by the five senses. Oh, I forgot mentioning the sixth sense. If I remember correctly, there is a professor

specializing in "sixth sense engineering." Sixth sense engineering naturally involves the realm of philosophy, so it must be difficult to deal with.

It is well known that dolphins are intelligent. In fact, their cerebrum is far larger than that of humans and has capabilities beyond humans, allowing them, for example, to hear supersonic waves, which is used to measure the distance between the target and the dolphin itself.

Chimpanzees are another example. They have a cerebrum that has evolved to acquire a structure similar to that of humans. Sometime in the far future, their cerebrum may evolve to the extent that they come to have a mind like ours. If it becomes a reality, we may see a world as depicted in the movie "Planet of the Apes."

Let's return to the main subject. Of stimuli that come into the five human sensors (senses of sight, hearing, touch,

smell and taste), stimuli for sight are said to have the greatest impact on our brain. It is known that eye fatigue significantly influences our brain activity. With online shopping, you can purchase your eyeglasses simply by declaring your optical power level even if it is outdated. It is dangerous because you run the risk of wearing glasses that do not match your actual optical power level. If that is the case, according to a research report, your brain will continue to be put under stress, which may lead to poor memory.

"Brain" is a simple word, but the world of the brain is so deep that many questions remain unresolved. The ultimate question is: "Why did the mind (feelings) come into being?"

I occasionally think "If only I had no feelings . . ." But as I wake up the following morning, I always breathe a sigh of relief, saying to myself "Fortunately, I still have feelings." This is another function of feeling, isn't it?

## Science and Technology Information

### The 13th KEIO TECHNO-MALL 2012 "Passion of Science, Enthusiasm of Engineering"

<http://www.kll.keio.ac.jp/ktm/>

Date: December 7 (Fri.), 2012 10:00 ~ 18:00

Tokyo International Forum (Exhibition Hall 2, Basement 2)

Admission free, no prior registration required

The KEIO TECHNO-MALL, organized by KLL, is an annual exhibition of science and technology. For this year, a round-table session by researchers will be held in addition to some 80 exhibition booths and demonstrations. The main event is on the theme "Science, Creation, Emotion" which will feature a keynote speech by the novelist Mr. Hideaki Sena and a talking session by researchers from the Keio Faculty of Science and Engineering.

### The 16th KLL Industry-Academia Collaboration Seminar

<http://www.kll.keio.ac.jp/>

Date: February 22 (Fri.), 2013

This seminar will introduce our research activities related to "precision machining", "actuation" and "simulation" which are the core themes of mechanical engineering. Details of this seminar will be published on the above website.

### Editor's postscript

Associate Professor Yasue Mitsukura's character is so diverse that it's very difficult to describe her personality in one word. On one hand, she appears to be a "bulldozer" type because she is very powerful and completes jobs vigorously. On the other hand, when the bulldozer has passed, she turns into a "roller" making fine adjustments to bring the job to perfection. If you think of the nature of researchers, no wonder one researcher is required to play diverse roles, such as a designer, power shovel, bulldozer, roller and crane.

Ms. Mitsukura has worked for more than one university in the past, but in the interview for this issue she mentioned, "I've found a comfortable haven at Keio." More than one student in the doctor's course already belongs to her lab. I sincerely hope that research work at the Mitsukura lab will become more and more prosperous under Keio's culture of freedom and solidarity.

(Saori Taira)



A scene from the 15th KLL Industry-Academia Collaboration Seminar

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