UTokyo-IIS Bulletin

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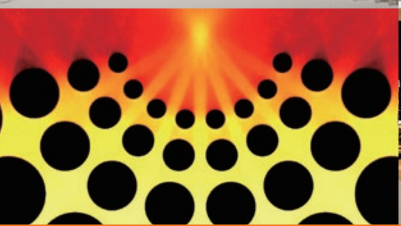
Institute of Industrial Science, The University of Tokyo








東京大学生産技術研究所
Institute of Industrial Science, The University of Tokyo

Prototyping the future:

Fusing state of the art science and technology with innovative design engineering

UTokyo-IIS holds the 70th Anniversary Exhibition *POTENTIALITIES: Exhibition For A Possible Future*, 1-9 December 2018, at the National Art Center, Tokyo to commemorate the Institute' s 70th anniversary.

https://www.iis.u-tokyo.ac.jp/event/moshikasuru/en/

Shunji Yamanaka is internationally renowned for his unique contributions to industrial design that have been recognized by his peers in the form of awards that include the *Mainichi Design Prize, iF Good Design Award* (Germany), and the *Good Design Award*. More recently, in 2010 Yamanaka's *Tagtype Garage Kit* was chosen for exhibition as a permanent collection at the Museum of Modern Art (MoMA) in New York.

"As a mechanical engineering student at the University of Tokyo I really enjoyed drawing, in particular manga characters," says Yamanaka. "So when I graduated in 1982 I joined the design team of a Japanese automobile company. This vocation enabled to me combine my training as a mechanical engineer with my deep interest in drawing as a design engineer. This was the beginning of my career in industrial design."

In 1987 Yamanaka began working as an independent designer, eventually setting up his company, LEADING EDGE DESIGN in 1994, and in 2013 he accepted a faculty position at UTokyo-IIS. "I have designed many kinds of industrial products in my career such as cameras, furniture, information technology devices, and wristwatches," explains Yamanaka. "And, with the launch of the Design-Led X Platform in 2017, I want use my experience as a design engineer to contribute to the discovery of fruitful interaction between man and technology. The 70th Anniversary Exhibition is an example of events that we are organizing to increase global awareness for greater interaction between scientists, engineers and designers."

Director

Shunji Yamanaka, Professor

Planning the 70th Anniversary Exhibition
POTENTIALITIES: Exhibition For A Possible Future

"This exhibition was really challenging," says Mai Tsunoo who worked with the 70th Anniversary Exhibition Working Group on organizing the event. "We were given 1000 square meters of space to exhibit items representing a wide cross-section of research being undertaken at UTokyo-IIS. This is a huge space to cover! Also, this exhibition was open to the general public, so it was designed to appeal and connect with people of all ages, gender, and from many walks of life." The exhibits consisted of prototypes of the results of research conducted at UTokyo-IIS, including items offering insights into the key technology at the core of the discoveries and inventions.

The exhibition posed questions and encouraged visitors to use their imaginations to find solutions by examining exhibits on display and thereby, possibly, glimpse the future:

What would happen if a machine read our emotions?
Is it possible to create a beautiful prosthetic leg?
What would it look like if we floated basketball-sized probes on the Earth's oceans?

"The exhibits included robots whose components were all made by 3D-printing," explains Yamanaka. "We wanted visitors to be surprised by the fact that robots were not assembled one piece at a time, but made entirely by 3D-printers, from the inside out. This would convey the future of manufacturing technology. Also, some exhibits were made of meta-materials that enable the fabrication of structures possessing many different kinds of textures but from the same material. Again a view of the future."

Approximately 10,000 people visited the exhibition over the duration of the 10 days. "They included many young people and parents who wanted their children to see the exhibits," says Ms Tsunoo. "The event was a tremendous success."

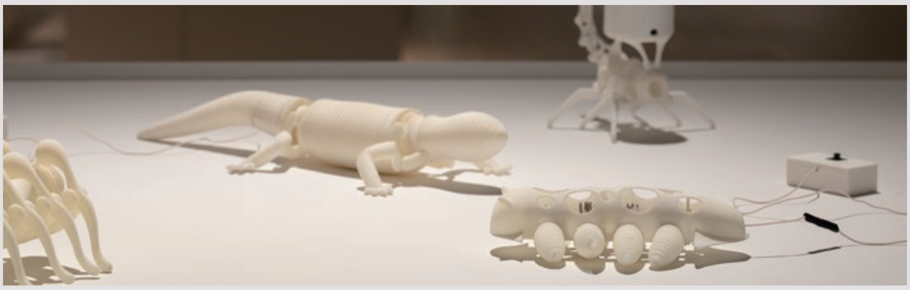


Exhibit composition and text

Mai Tsunoo,
Design Writer / Curator

Design engineering to prototype the future

Yamanaka believes that industrial design will play an increasingly important role in shaping the global society of the future. "We are moving away from the long held belief that design and engineering are unrelated," explains Yamanaka. "The huge divide that existed between scientists, engineers, and specialists working in advanced research has been removed by the proliferation of information via the internet. Images and video about the latest technological developments reach a global audience at the speed of light. So prototyping will play a major role in giving visions of the future by connecting advances in technology with society in general."

Yamanaka and Design-Led X Platform are producing prototypes for technology related to robotics, medicine, and manufacturing to connect the futuristic ideas technologists with the dreams of consumers.

Further information

Yamanaka Laboratory
http://www.design-lab.iis.u-tokyo.ac.jp/

Design-Led X Platform
http://www.designledx.iis.u-tokyo.ac.jp/

The Disaster Management Training Center (DMTC) is established


Muneyoshi Numada, Associate Professor

Education and training based on customized programs to nurture critical thinking to respond to natural disasters

September 1st is the national Disaster Prevention Day in Japan—a date chosen to remind people of the 1923 Great Kanto earthquake disaster that occurred on this day, taking over 100,000 lives. Every year on this day, school children, staff and students at universities, company employees, hospital staff, and other people living in Japan, practice disaster prevention drills. Drills designed to save lives in the event natural disasters due to earthquakes, tsunamis, typhoons, and even volcanic eruptions—there are about 110 active volcanoes in Japan.

Needless to say Japan is high on the list of countries prone to natural disasters, with recent examples including the massive earthquake off the Pacific coast in Tohoku that triggered a tsunami in 2011; volcanic eruption of Mount Ontake in 2014, killing 58 people; and floods in western Japan in July 2018; Hokkaido earthquake in September 2018.

Surprisingly, and despite the long history of natural disasters in Japan, there is still room for improvement to disaster management. “In the USA, Federal Emergency Management Agency (FEMA) coordinates responses to disasters that cannot be handled by local authorities,” explains Muneyoshi Numada, one of the directors of the Disaster Management Training Center (DMTC). “FEMA spends millions of dollars on training people across the whole of the country to cope with major disasters. Hundreds if not thousands of people in the USA share knowledge and personal experiences of disaster management at highly coordinated training programs with excellent contents and facilities. Japan can learn from such nationwide programs to improve its disaster management response. Here, local authorities use their own manuals and procedures, and, there are very few highly trained disaster management experts in Japan. The DMTC was set up to resolve these problems. We have developed powerful, comprehensive programs to train people to handle disasters irrespective of the location. The DMTC is the first such training center in Japan.”

BOSS management platform: Critical thinking for disaster response

The DMTC addresses the reality of social issues in Japan related to the decreasing birthrate, aging population, and constraints on public spending for national aid programs in the context of disaster management. "We want to encourage people to think about self-help and cooperation, in dealing with disasters," says Numada. "We cannot always rely on national support to handle disasters, especially, immediately after an earthquake, for example."

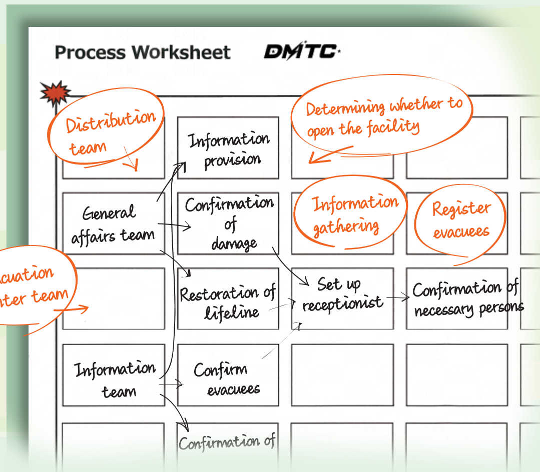
To-date, local authorities and the government have introduced wide ranging training and countermeasures to handle disasters. However, as seen by the 2016 Kumamoto earthquake, the response by local governments and residents was confused or dysfunctional, highlighting the need for improvements in training programs for disaster management.

With this background The University of Tokyo Interfaculty Initiative in Information Studies (UTokyo-III), The Center for Integrated Disaster Information Research (CIDIR) and UTokyo-IIS, International Center for Urban Safety Engineering (ICUS) launched the DMTC to undertake systematic and practical training to improve the ability of citizens, officials from local, prefectural and national authorities, to respond to disasters.

The education and training offered at the DMTC is based on programs developed by research groups at UTokyo-III and IIS in collaboration with industries affiliated with the Foundation for the Promotion of Industrial Science (F.P.I.S).

"The important and distinctive feature of the DMTC is that our programs are based on standardizing training for managing disasters," explains Numada. "So all the people trained here will have a universal approach and be able to handle a wide range of disasters. They will be able to communicate with each other using the same terminology, without confusion and hesitation. We want to create a new mindset to handle disasters."

The programs at the DMTC are based on global standards using the latest knowledge and technology during training. At the heart of the IIS is a huge 'disaster management flow chart' that was developed by Numada and colleagues. "Our BOSS (BOSai System, Business Operation Support System) enables trainees to optimize their response and workload during disasters," explains Numada. "Each trainee eventually produces a customized response chart for their particular circumstances. The trainees share this information with their colleagues, and update charts during subsequent training sessions. It's a living chart for disaster response!"



Numada has used the BOSS system in actual disaster management including the Kumamoto earthquake (April 2016) and flooding in Kurashiki, Okayama (July 2018). He has been giving seminars about it in Indonesia, India, Bangladesh, Myanmar, and plans to extend his activities across the ASEAN region to standardize disaster management. "Ultimately the most important point of our training is critical thinking, more specially, 'not what decision to make' but 'how to make a decision'."

Further information

DMTC
(Disaster Management Training Center, III, CIDIR/ IIS, ICUS, The University of Tokyo.)
http://tdmtc.tokyo/

BOSS
(BOSai System, Business Operation Support System)
http://www.numa.iis.u-tokyo.ac.jp/top.html#About

KOMABA RESEARCH CAMPUS INTERNATIONAL DAY 2018

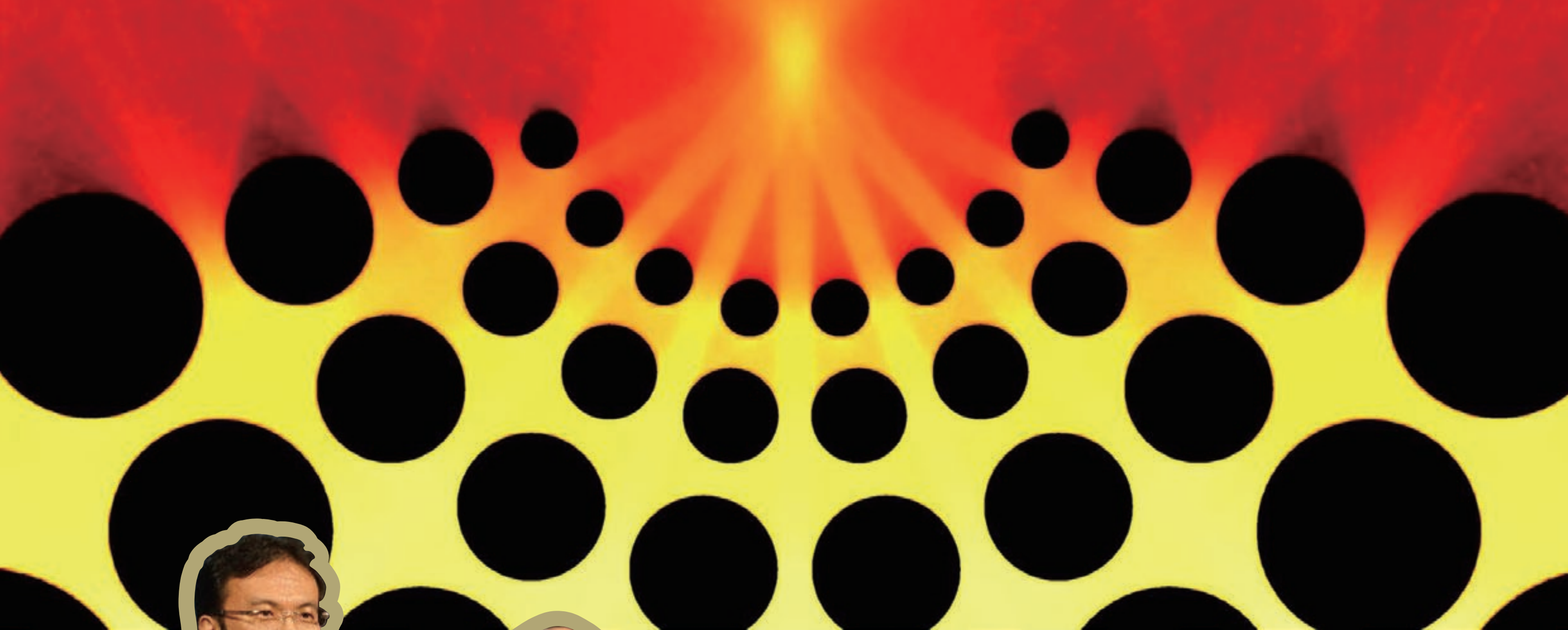
At UTokyo-IIS, we promote international academic and cultural exchanges to enhance our research activities and social impact. On October 4th, the Komaba Research Campus International Day 2018 was held to promote friendship among domestic and foreign researchers, faculties, and students in IIS and UTokyo-RCAST (Research Center for Advanced Science and Technology).

9 cultural presentations/performances by international students/researchers from various places including Belarus, China, France, India, Mexico, Pakistan, Russia, Taiwan, U.S. and Japan were conducted. The presentations introduced cultural highlights and differences from various aspects including food, wedding, social life, music, dance, language, etc. After the presentations, the audience enjoyed the sound and rhythm of Japanese drum by 8 performers from Wadaiko Dojo Dondoko (Japanese drum playing society Dondoko). They explained Bon-Odori drum beats in English and many attendees had a chance to perform on the stage. At the social get-together, participants enjoyed international friendship with cuisines from various countries.

This joyful event attracted a crowd of over 320 participants, which provided a great opportunity to enjoy the cultural exchange and feel the diversity of Komaba research campus.

Further information https://www.iis.u-tokyo.ac.jp/en/international/researcher/

MASAHIRO NOMURA WINS THE GERMAN INNOVATION AWARD "FOR TREATING HEAT LIKE LIGHT."



Left : Masahiro Nomura,
Right : Masuo Aizawa, Selection committee chairman

German Innovation Award - Gottfried Wagener Prize 2018 was presented to Associate Professor Masahiro Nomura at UTokyo-IIS on 26 June 2018 "for thermal conduction control by phonon engineering and thermoelectric energy harvesting application."

Since heat dissipation is a problem in many optical and electrical devices, thermal conduction is a common facet of everyday life. The phenomenon of thermal conduction can be explained in terms of the vibrating lattices that carry heat as quasi particles called phonons. The ability to control phonons, which have wave-like properties, within solids has opened up the new field of phonon engineering (heat transfer engineering). The physicist Masahiro Nomura is engaged in efforts to control thermal conduction through this method. By creating periodic, circular, nanometer-size holes in a thin silicon film through nano-processing, Associate Professor Nomura and his associates have produced heat flow in a specific direction and have realized the heat focusing at a single point within a solid for the first time. By doing so, they have overturned the commonly accepted notion that heat diffuses in all directions. They have also demonstrated that control of thermal conduction based on wave property is possible by altering the periodic properties of these artificial crystal structures, which are called phononic crystals. This pioneering experiment has shown that advanced thermal control can be accomplished through the design of nanostructures. Furthermore, through joint research conducted with Professor O. Paul's group in the University of Freiburg in Germany, Associate Professor Nomura and his associates have greatly enhanced the thermoelectric conversion capabilities of silicon-based materials by applying multi-scale structures to thermal phonons distributed over a wide range of frequency levels.

These results not only contribute to the resolution of heat dissipation issues for semiconductor chips and other materials, but are also important for the creation of innovative technologies in the field of energy harvesting (environmental power generation) through thermoelectric conversion. As the pioneer of a new field, Associate Professor Nomura envisions using the wave properties of heat and "treating heat like light" as "one of the important themes for scientific and energy problems in the 21st century."

Further information Nomura Laboratory **http://www.nlab.iis.u-tokyo.ac.jp/index_E.html**

Terahertz Spectroscopy Enters the Single-Molecule Regime

Researchers use terahertz radiation to study ultrafast dynamics of single fullerene molecules

The interaction of light with matter is the basis of spectroscopy, a set of techniques lying at the heart of physics and chemistry. From infrared light to X-rays, a broad sweep of wavelengths is used to stimulate vibrations, electron transitions, and other processes, thus probing the world of atoms and molecules.

However, one lesser-used form of light is the terahertz (THz) region. Lying on the electromagnetic spectrum between infrared and microwaves, THz radiation does have the right frequency (around 10^{12} Hz) to excite molecular vibrations. Unfortunately, its long wavelength (hundreds of micrometers) is around 100,000 times a typical molecular size, making it impossible to focus THz beams onto a single molecule by conventional optics. Only large ensembles of molecules can be studied.

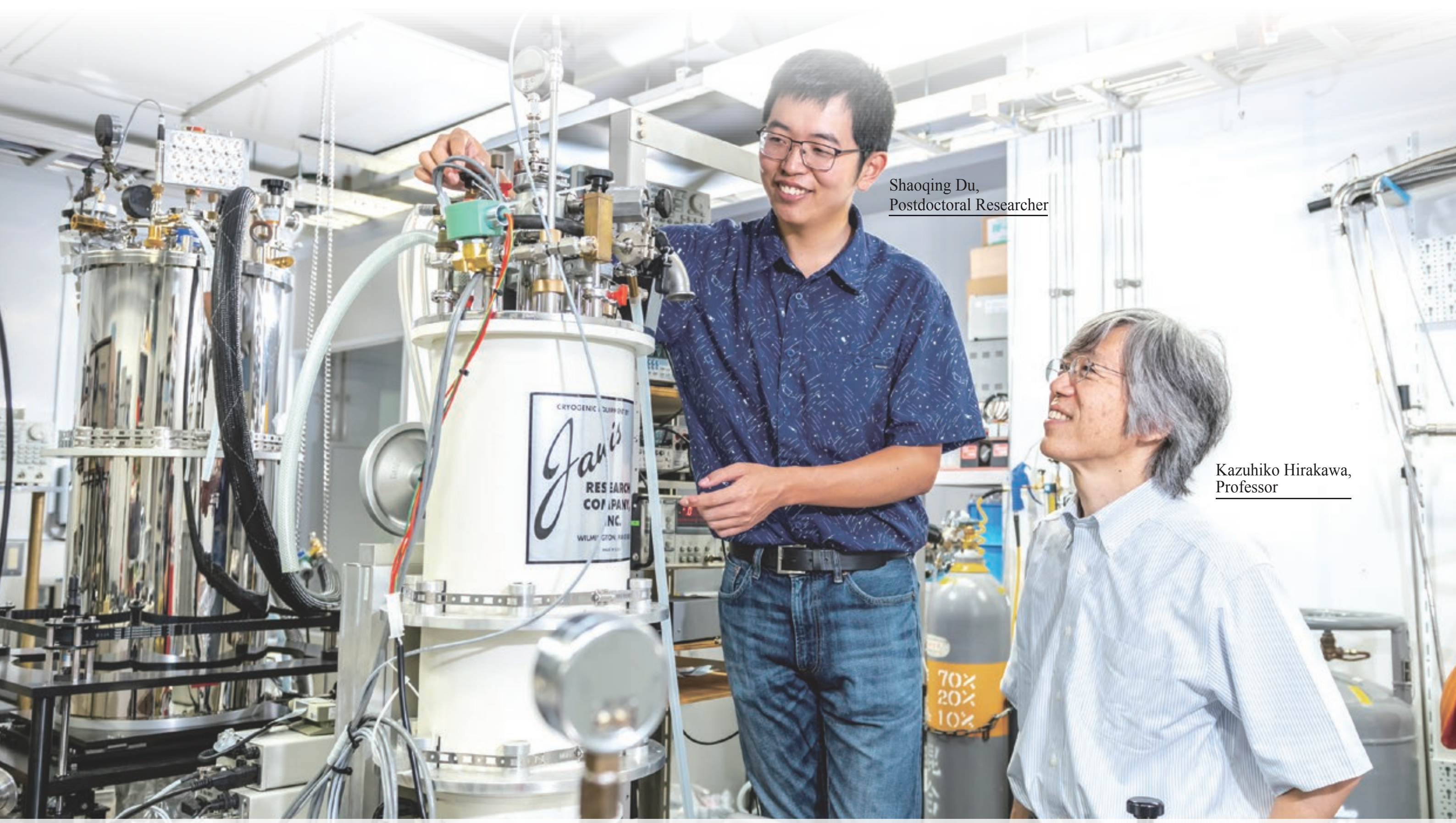
Recently, a team led by UTokyo-IIS found a way around this problem. In a study in *Nature Photonics*, they showed that THz radiation can indeed detect the motion of individual molecules, overcoming the classical diffraction limit for focusing light beams. In fact, the method was sensitive enough to measure the tunneling of a single electron.

The IIS team showcased a nanoscale design known as a single-molecule transistor. Two adjacent metal electrodes, the source and the drain of the transistor, are placed on a thin silicon wafer in a "bowtie" shape. Then, single molecules—in this case C_{60}, aka fullerene—are deposited in the sub-nanometer gaps between the source and drain. The electrodes act as antennas to tightly focus the THz beam onto the isolated fullerenes.

"The fullerenes absorb the focused THz radiation, making them oscillate around their center-of-mass," explains study first-author Shaoqing Du. "The ultrafast molecular oscillation raises the electric current in the transistor, on top of its inherent conductivity." Although this current change is minuscule—on the order of femto-amps (fA)—it can be precisely measured with the same electrodes used to trap the molecules. In this way, two vibrational peaks at around 0.5 and 1 THz were plotted.

In fact, the measurement is sensitive enough to measure a slight splitting of the absorption peaks, caused by adding or subtracting only one electron. When C_{60} oscillates on a metal surface, its vibrational quantum (vibron) can be absorbed by an electron in the metal electrode. Thus stimulated, the electron tunnels into the C_{60} molecule. The resulting negatively charged C_{60}^- molecule vibrates at a slightly lower frequency than neutral C_{60}, thus absorbing a different frequency of THz radiation.

Apart from providing a glimpse of tunneling, the study demonstrates a practical method to obtain electronic and vibronic information on molecules that only weakly absorb THz photons. This could open up the wider use of THz spectroscopy, an under-developed method that is complementary to visible-light and X-ray spectroscopy, and highly relevant to nanoelectronics and quantum computing.



Reference
Shaoqing Du, Kenji Yoshida, Ya Zhang, Ikutaro Hamada, and Kazuhiko Hirakawa
"Terahertz dynamics of electron-vibron coupling in single molecules with tunable electrostatic potential"
Nature Photonics(2018), doi: 10.1038/s41566-018-0241-1

SNAPSHOTS OF THE FUTURE: TOOL LEARNS TO PREDICT USER'S GAZE IN HEADCAM FOOTAGE

Researchers have developed a computational model that can learn from headcam-acquired video footage where the user's attention is likely to be focused during specific tasks, which could lead to numerous supplementary applications for headcam technology.

The miniaturization of video cameras has led to an explosion in their use, including their incorporation into a range of portable devices such as headcams, used in scenarios ranging from sporting events to armed combat. To analyze tasks performed in view of such devices and provide real-time guidance to individuals using them, it would be helpful to characterize where the user is actually focusing within footage at each moment in time, but the tools available to predict this are still limited.

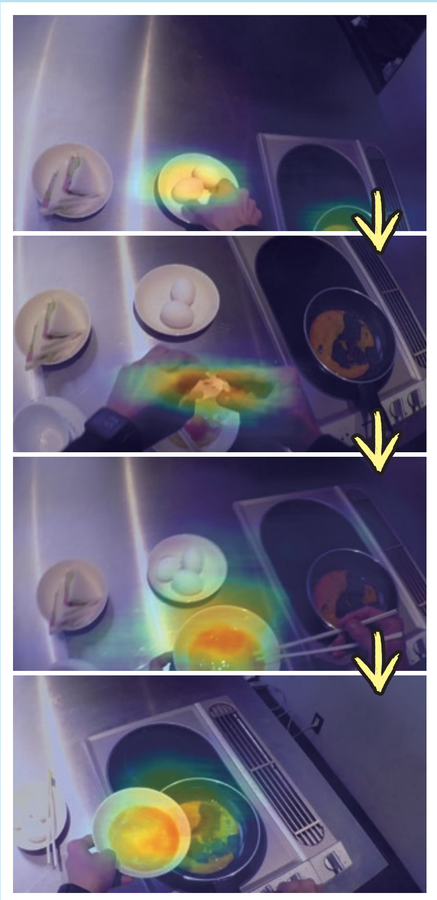
In a new study reported at the 15th European Conference on Computer Vision (ECCV 2018), researchers at UTokyo-IIS have developed a computational tool that can learn from footage taken using a headcam, in this case of various tasks performed in the kitchen, and then accurately predict where the user's focus will next be targeted. This new tool could be useful to enable video-linked technologies to predict what actions the user is currently performing, and provide appropriate guidance regarding the next step.

Existing programs for predicting where the human gaze is likely to fall within a frame of video footage have generally been based on the concept of "visual saliency," which uses distinctions of features such as color, intensity, and contrast within the image to predict where a person is likely to be looking. However, in footage of human subjects performing complex tasks, this visual-saliency approach is inadequate, as the individual is likely to shift their attention from one object to another in a sequential, and often predictable, manner.

To take advantage of this predictability, in this study the team used a novel approach combining visual saliency with "gaze prediction," which involves an artificial intelligence learning such sequences of actions from existing footage and then applying the obtained knowledge to predict the direction of the user's gaze in new footage.

"Our new approach involves the construction of first a 'saliency map' for each frame of footage, then an 'attention map' based on where the user was previously looking and on motion of the user's head, and finally the combination of both of these into a 'gaze map,'" Yoichi Sato says. "Our results showed that this new tool outperformed earlier alternatives in terms of predicting where the gaze of the headcam user was actually directed."

Although the team's results were obtained for footage of chores in a kitchen, such as boiling water on a stove, they could be extended to situations such as tasks performed in offices or factories. In fact, according to lead author Yifei Huang, "Tools for evaluating so-called egocentric videos of this kind could even be applied in a medical context, such as assessing where a surgeon is focusing and offering guidance on the most appropriate steps to be taken next in an operation."



Yoichi Sato, Professor

Reference

The article "*Predicting Gaze in Egocentric Video by Learning Task-dependent Attention Transition*" is published in the proceedings of European Conference on Computer Vision (ECCV 2018) and as an arXiv paper at **https://arxiv.org/abs/1803.09125**

Interpretation of material spectra can be data-driven using machine learning

Modern spectroscopy techniques can produce tens of thousands of spectra from a single experiment, which has placed a considerable burden on traditional human-driven methods for interpretation of these spectra. A research team led by Teruyasu Mizoguchi combined two machine learning techniques, layer clustering and decision tree methods, to produce data-driven methods for spectral interpretation and prediction that can analyze any spectral data quickly and accurately.

Scientific Reports(2018), doi: 10.1038/s41598-018-30994-6

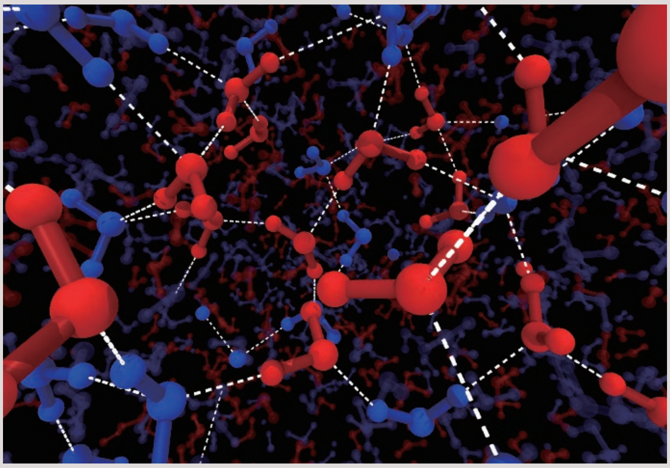
Further information https://www.iis.u-tokyo.ac.jp/en/news/2967/

Fast vs Slow Water: Explaining the Fragile-to-Strong Transition

A research team led by Hajime Tanaka investigated the fragile-to-strong transition of water. Unlike most liquids, when water is cooled, the rate of increase of its viscosity reaches a maximum at a certain low temperature. The team showed that modeling water as a temperature-dependent mixture of two states—disordered "fast" water and locally ordered "slow" water—explained the fragile-to-strong transition and avoided the faulty predictions of earlier theories based on glassy behavior.

PNAS(2018), doi: 10.1073/pnas.1807821115

Further information https://www.iis.u-tokyo.ac.jp/en/news/2960/

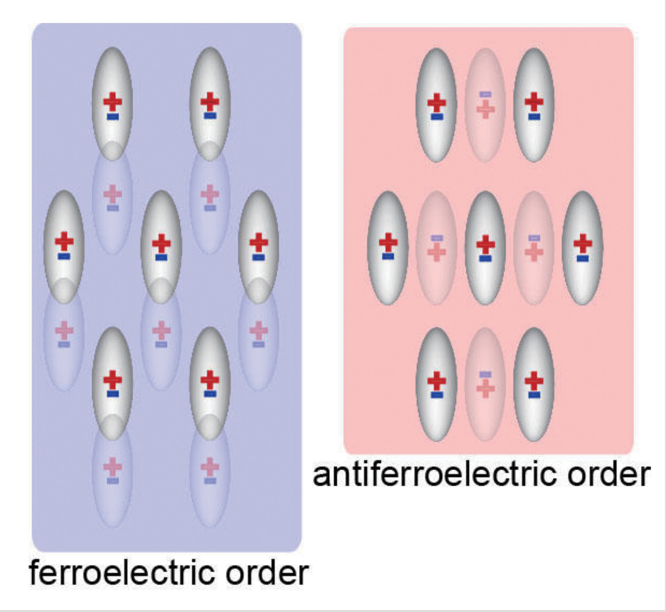


Modeling crystal behavior: Towards answers in self-organization

Kohei Takae and Hajime Tanaka have created a model to explore the transition behavior of crystal lattices. Their system, based on spheroid particles with a permanent dipole, showed that the combination of anisotropic steric and dipole effects causes frustration that induces the coupling between polarization and strain, resulting in the self-organization. These findings are expected to contribute to the rational design of materials for applications including electro-mechanical actuators and electro-caloric refrigerators.

PNAS (2018), doi: 10.1073/pnas.1809004115

Further information https://www.iis.u-tokyo.ac.jp/en/news/2975/



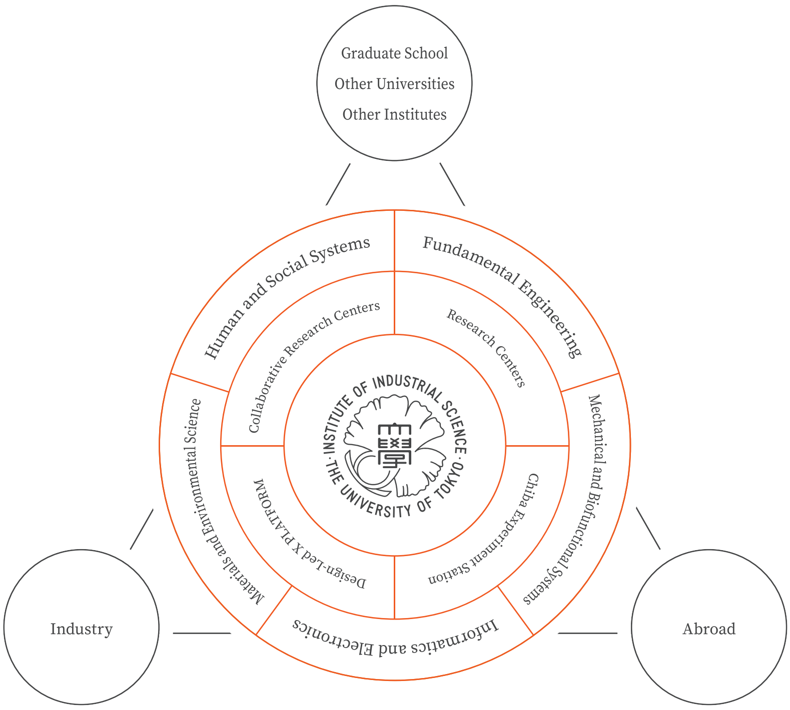
Since its establishment in 1949, the Institute of Industrial Science at the University of Tokyo(UTokyo-IIS) is one of the largest university research institutions in Japan and its history reaches 70 years.

Our multidisciplinary research covers nearly all fields of engineering, and our professors, associate professors, and lecturers each lead dedicated laboratories, about 120 in total. More than 1,000 personnel, comprising approximately 300 faculty members including staffs and 750 graduate students, participate in educational and research activities that are responsible for producing excellent research outcomes and fostering outstanding talent. All our laboratories belong to one of five core research departments and some straddle multiple departments, providing the warp and weft for nine research centers, three collaborative research centers, and two international collaborative research centers. As well as promoting original research in each specialist field, we as an institution encourage cross-disciplinary and international activities. Last year saw the functions of the Chiba Experiment Station transferred from its original home in Nishi-Chiba to our Kashiwa campus, and the launch of the new Design-Led X Platform.

Since the foundation of the Institute, we have been acutely aware that the significance of academic research into engineering lies in its real-world implementation, and together with the seeding of new academic disciplines through enhanced specialization and cross-disciplinary collaboration, we have developed and deployed new technologies that contribute to solving problems in the real world. We have also made it our mission to nurture talented people to shoulder the responsibility of technological development and dissemination, especially in the industrial world. Such a philosophy and sense of mission has been programmed into our DNA since the foundation of the Institute, and we have taken a hands-on approach to address engineering challenges as a pioneer of advocacy for collaboration between industry and academia. We also take pride in the fact that our achievements and proactive stance are widely recognized together with the name *Seiken*.

Society is facing diverse problems today, and expectations are growing for the role that engineering plays in solving these problems. At the same time, the challenge for conventional engineering is that it is unable to make widely-accepted and compelling products with an approach that focuses only on technological development. For such situations that are difficult to address with engineering alone, we are seeking to build a new *Seiken* style—one that contributes to the creation of compelling value through innovation, founded on the pursuit of academic truth as a university research institute, and adding a multidisciplinary approach integrating humanities and sciences that incorporates exit strategies for real-world implementation, to the style that it is long known for: barrier-free, cross-disciplinary, practical industry–academia collaboration, and ambitious international collaboration.

Even though it is the largest of its kind in Japan, *Seiken* is perfectly sized to maintain a strong sense of organizational unity, and through our agility and collective strength as a world-class research institute in the field of engineering, we hope to continue helping to make everyone's dreams come true.



Five Research Departments and Research Centers

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