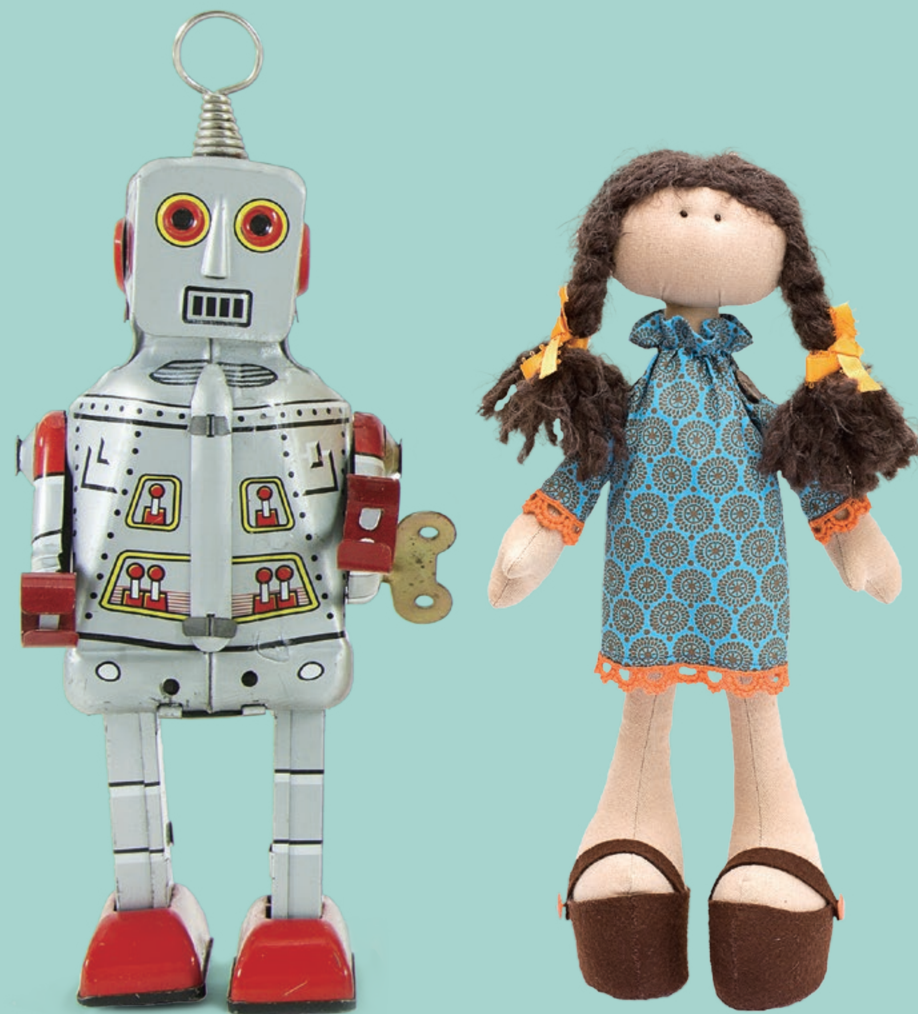
ENG ENG

RADIANT

RITSUMEIKAN UNIVERSITY

Ritsumeikan University Research Report



[Special Feature]

The Future of Machines and Humans

ISSUE 6

July 2017

RADIANT

Division of Research, Ritsumeikan University

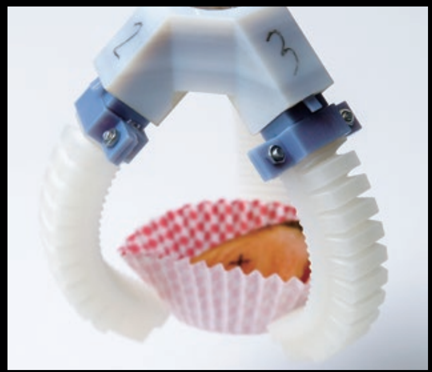
http://en.ritsumei.ac.jp/research/

RITSUMEIKAN UNIVERSITY

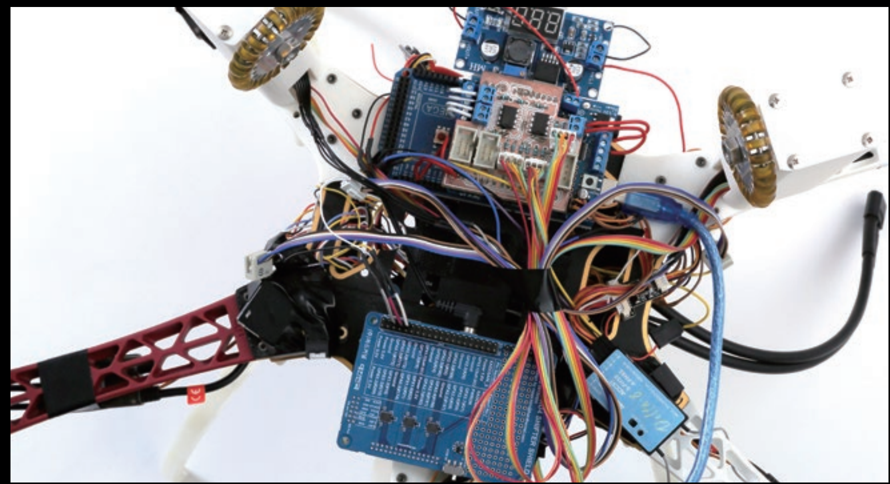
The future is shining brightly
Ritsumeikan research activities
that enlighten the world

The Future of Robots and AI

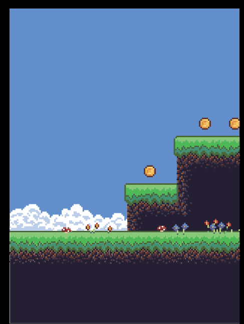
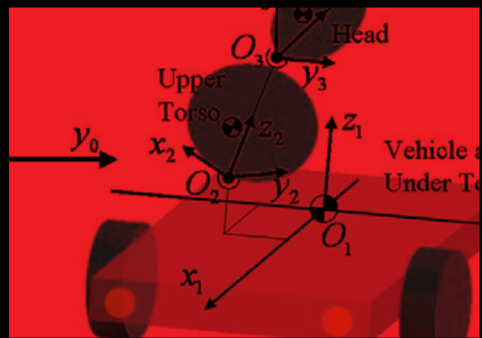
Thanks to function sophistication and quality improvement, machines have greatly contributed to increases in productivity and convenience for a wide range of human activities, in addition, of course, to liberating human workers from heavy loads and arduous labor. At the same time, as illustrated by situations in which machines make use of people, what society demands now are human-friendly machines that can co-exist with people. Going forward, what role should machines play and what sort of relationships should they have with human beings? Against this backdrop, Ritsumeikan University is tackling numerous research projects from diverse angles across a range of academic fields.

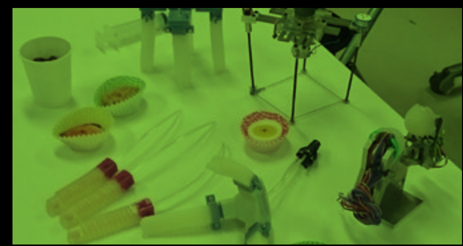










Robotics and Artificial Intelligence (AI) are research fields currently attracting a great deal of attention. Sadao Kawamura, professor of the College of Science and Engineering, who also serves as the director of the Robotics Research Center, and Tadahiro Taniguchi, professor of the College of Information Science and Engineering, who addresses R&D for AI from new perspectives, held enthusiastic and open dialogues on robotics and AI research, along with the relationship between the two, into the future.

Increased focus on robotics and AI, based on technological innovation

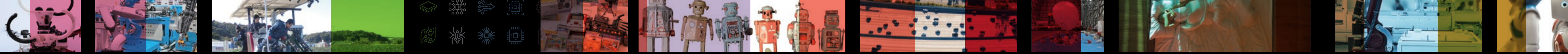
To understand your research position, please introduce yourself.

Kawamura: My background is in bioengineering. During my master's, I changed specialization to mechanical engineering and began the study of robots. Since 1987, when I began teaching at Ritsumeikan University, I have been involved in the development of robots by combining mechanical and control technologies. The development of underwater robots is one example of this. Recently, I am also working on a study of soft robotics making use of soft materials.

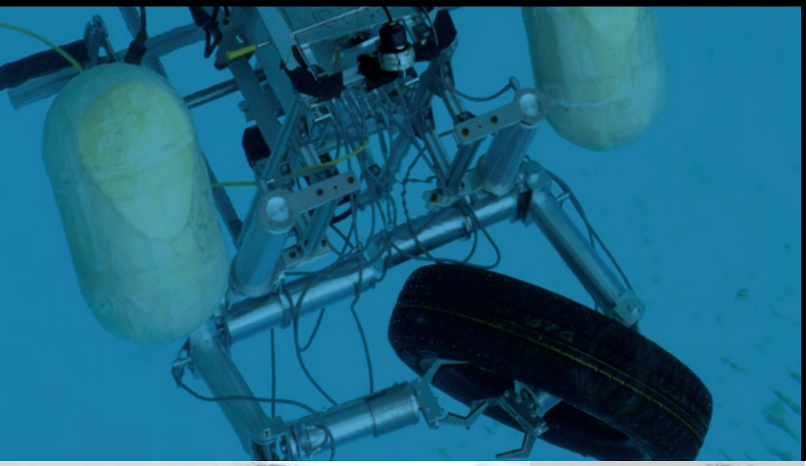
Taniguchi: In contrast to Dr. Kawamura, I majored in the mechanical engineering first. I obtained a doctoral degree of engineering and then moved on to information science. The second AI boom of the 1980s had come and gone before the moment, with the limits of AI being pointed out as per a computer's processing capabilities. In response to this, our research community gave more attention to the importance of the "body." Human beings build cognition based on physical experience and communication with people around them and their relationships in society in a bottom-up manner. To overcome the limits of the then-existing AI, we thought it was necessary to have AI acquire languages and concepts using the same process as human cognitive development. We thus defined a robot as a computer that has a "body" interacting with external forces, and identified the new approach of "Symbol Emergence in Robotics" and carried out studies based on this.

More than 30 years have passed since the second AI boom. It is now said that we are being in a robot boom and that a third AI boom has already arrived. Why are robots and AI attracting so much attention again?

Table of Contents



Kawamura: One of the main reasons for this robot boom is the development of technology. For example, with element technologies such as sensors, actuators, and computers constituting robots, the technologies to actually integrate them have drastically evolved. In addition, there are increasing social needs. With a decrease in working populations due to declining birthrates and aging populations, especially in advanced countries, and accelerated reshoring of manufacturing, it is quite apparent that sooner or later, the manufacturing industry will be unable to keep pace without automation



Sadao Kawamura

Professor, College of Science and Engineering

Born in 1956. Graduated from Department of Biological Engineering, Faculty of Engineering Science, Osaka University in 1981 and completed the Mechanical Engineering Doctoral Course, Division of Engineering Science, Graduate School of the same university (Doctor of Engineering) in 1986. Served as an assistant at Osaka University in the same year, assistant professor of the Department of Mechanical Engineering, College of Science and Engineering, Ritsumeikan University in 1987, and later as professor. In 1996, along with the establishment of the Department of Robotics, appointed professor of said department. Between April 2003 and December 2006, appointed vice president of Ritsumeikan University. Associate member of the Science Council of Japan from 2006 up to the present date. President of the Robotics Society of Japan between 2011 and 2013. Chairman of the Robotics Subcommittee of the Science Council of Japan since 2016. Engaged in the Robot Revolution Initiative as a councilor from 2015 up to the current date.

using robots. As illustrated by the market expansion detailed in the New Robot Strategy by the Ministry of Economy, Trade and Industry, robot development is now an important challenge that clearly needs to be embarked on all over Japan.

Taniguchi: This current, third AI boom is being driven by deep learning and other machine learning technologies. One of the contributors of this is, as is the case with the robot boom, the evolution of element technology. In brief, it all boils down to increased computer processing speed and capacities, plus the large volumes of data that can be generated, accessed, and shared via the prevalence of the Internet. This is obvious, as AI mega companies are represented by, for example, Google, Microsoft, and Facebook. Unfortunately, Japan is currently being outdone by these companies, in reality. We must first catch up with these forerunners and create innovative AI in view of what's coming "next."

Developing robots and AI: Turning popular concepts upside down

As with the notion of automobile robotization, robots of diverse shapes and functions beyond the imagination of the general public have appeared one after the other.

Kawamura: I have had some misgivings about the high level of ambiguity in the definition of "robots" for a long period of time. The shapes and functions of a robot must be determined by the robot's purpose, and assuming without a reason that "robots should be like this" may hinder robot development. For example, if "robots should be humanoids," we need to add parts and components unnecessary for essential functions to make a "cleaning robot" a humanoid. This would become unfeasible in terms of both engineering and cost.

The soft robots that you (Dr. Kawamura) are studying are turning the popular concepts of robots upside down. Am I correct to assume this?

Kawamura: Most robots playing a role in society now have a rigid body made of heavy metallic materials. On the contrary, I am trying to create "soft" robots using polymer materials such as plastics and rubber, in place of these metals. By using soft materials, weight and cost reductions become a possibility. Furthermore, not only is the material soft but we can also realize flexible and smooth actions, like a human, thereby expanding application potential to a large degree.

That said, changing materials is a lot easier said than done. As most robot dynamics and control theories conventionally based on metals cannot be applied, we need to build theories for soft robotics from scratch. I believe it is a university's role to assume the responsibility to build and develop theories that cannot be carried out by a private organization.

Taniguchi: Soft robotics is heavily related to the development of AI technology in the future. AI prior to the third AI boom was in fact "hard" AI that could learn through uniform methods. On the other hand, machine learning, which we are currently focusing on, can be referred to as "soft software" that can acquire knowledge from variety of things.

For robots and AI, is the path of evolution to become even closer to human beings?

Taniguchi: I am targeting AI that acquires knowledge via the same process as a human baby learning to understand its environment in a bottom-up manner. "Symbol Emergence in Robotics" is in fact the reverse engineering of human intelligence. Soft robotics can be understood in the same context. What humans are today is a result of adapting to the Earth's environment through evolution by natural selection. Considering the fact that almost all organisms on Earth, in particular, human beings, have soft forms, it can be said that soft robots stand to reason.

Necessity of system integrators linking software to hardware

Taniguchi: Excellent machine learning cannot be considered useful on its own in the real-world environment. It needs to function with hardware or robots cooperatively, and also with a synergetic effect. To create a robot that can properly function in a human environment, software that can flexibly respond to the evolution of hardware is required. Assuming that AI development will be carried out at companies closer to commercialization, it will become more and more important to integrate robotic hardware with AI software, while working on technological developments.

Kawamura: I completely agree. In my research, software control and hardware mechanisms are both necessary for the design of a robot that functions properly. We need system integration technology to integrate both mechanisms and control according to the purpose at hand. In addition, it is necessary to establish a theory as a foundation, not only as a realization, and this is a role that should be borne by universities.

Universities are also expected to develop system integrator personnel that can link hardware with software, across the barriers of mechanical engineering and information science.

Kawamura: Indeed, this is a difficult problem. In 1996, Ritsumeikan University established the Department of Robotics at the College of Science and Engineering for the nurturing of system integrators. Even now, we are engaged in endless effort involving substantial trial & error toward the development of human resources that can connect software to hardware.

Taniguchi: It is a matter of urgency to develop talented human resources that can integrate multiple knowledge from different fields of studies. However, there are some misgivings that we might end up bringing up human resources with zero specializations and that have studied multiple academic fields albeit incompletely. I believe they should first master a high level of specialization that will serve as a foundation and then enter other fields during their doctorial course. Ritsumeikan University entertains a leading number of cooperative projects between industrial enterprises and universities throughout Japan, producing many talented human resources ready and able to work in the industry. These very connections with the industrial world should serve as a strength for Ritsumeikan University in developing system integrators.

Kawamura: Dr. Taniguchi and I both have a career that spans different majors. However, specialist fields are now becoming increasingly fractionalized, with the number of people studying different fields decreasing all the time. It would be ideal if such education could be put into practice in doctoral courses.

Creation of next-generation robots and AI through interdisciplinary collaboration

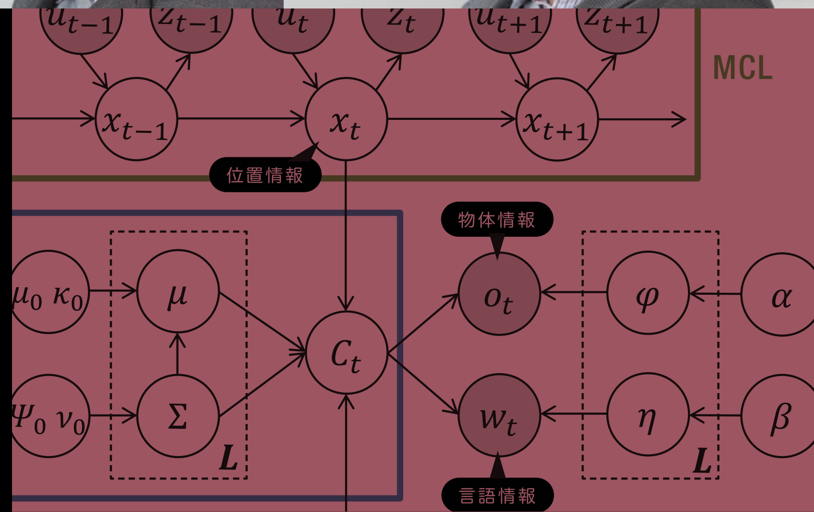
Both of you are engaged in the forming of Research Core, an interdisciplinary research project adopted by the Ritsumeikan Global Innovation Research Organization (R-GIRO). Please provide your outlook regarding the future of robots and AI research, including interdisciplinary collaboration.

Taniguchi: Going forward, from the viewpoint of "Symbol Emergence in Robotics," under a focus on the dynamism leading to human language acquisition and evolution, we will concentrate on AI studies and the social implementation of robots as an outcome. To understand the dynamism of human intelligence, we need basic research via interdisciplinary fusion in the truest sense. Ultimately, we aim to develop our R-GIRO research project as the core.

Tadahiro Taniguchi

Professor, College of Information Science and Engineering

Born in Kyoto in 1978. Completed a doctoral course at the Graduate School of Engineering, Kyoto University (Doctor of Engineering, Kyoto University) in 2006. After serving as an assistant professor and an associate professor at the College of Information Science and Engineering, Ritsumeikan University, assumed current position in 2017. Visiting associate professor at the Imperial College London between 2015 and 2016. Visiting general chief scientist at Panasonic engaged in R&D involving AI since 2017 (first cross-appointment case from a university to a corporation). Also known as the originator of Bibliobattle. Published materials include *Constructive Approach towards Symbol Emergence System* (NTT Publishing), *Symbol Emergence in Robotics* (Kodansha), and other titles.



Kawamura: I am also working on the development of soft robotics using advanced materials. Without a need to emphasize the importance of system integration, we cannot separate software from hardware in terms of robot development. In the development of soft robots, assistance from the "soft software" that Dr. Taniguchi mentioned will be essential. As for the challenges going forward, collaboration between the mechanical and information fields is sure to become more and more important.

Underwater Robots Acting as Gatekeepers of Lake Biwa's Environment

Lake Biwa is the largest lake in Japan. It is a very old lake, the shape of which has remained unchanged for about four million years. It has a rare presence in the world in that it has maintained a rich ecosystem up to the present day. Underwater robots now play active roles in its environmental conservation, and they also conduct investigations. COCO, developed by Sadao Kawamura and others, is an underwater robot capable of grabbing objects underwater, while using two arms. It has a small and lightweight body of 55 kg and is capable of diving to a depth of 50 meters, and it can pick up litter, capture video via an attached camera, and take measurements via an accelerometer, all at the same time. It has even been able to salvage old tires from the bottom of the lake.

Operating a robot on land is totally different than operating one in water, where it is affected by water pressure, buoyancy, and currents. With additional components such as highly flexible robotic arms, control becomes even more complicated. It is extremely difficult to move robotic arms on a floating underwater robot into proper positions, and in addition, when holding an object underwater without any foot-holding, the robot can lose balance due to the object's weight, and both the robot and the object can fall over. Kawamura developed an unprecedented and independent mechanism to shift the center of buoyancy as a means to solve such issues. This is a mechanism with two urethane foam float blocks and a screw that controls pitch and roll angles while maintaining the attitude of the robot body, successfully positioning this attitude toward underwater objects.

Kawamura's strength lies in his high skill regarding computer control technology and mechanical system development. "A robot is a synthesis of sensors, actuators, computers, and other things, to form a system," according to Kawamura. "Reliable performance cannot be expected without thinking from the viewpoint of system integration." The effects of an aquatic environment are still too unpredictable, while computer simulations are lacking, making the integration of mechanisms and control difficult. By overcoming this, however, Kawamura has realized unprecedented small-sized and high-performance underwater robots in quick succession.

"We attach importance to not only the performance of an underwater robot but also to ease in operation." If a robot can only be used by trained experts, whatever high-performance an underwater robot has would be a real waste of a valuable asset. Kawamura designs systems taking handling into consideration right from the start, so that the operation of robotic arms with a complicated control mechanism can be controlled via just a single joystick.

ARTEMI, an evolution of COCO, is lighter and weighs 30 kg. It can move much more quickly than COCO, and can grip objects and perform assembly with its arms at the front. By communicating the underwater situation via a camera and a 150-meter cable to the operator on the surface, complicated operations such as sticking long, narrow pipes into underwater silt become possible.

Prior to these robots, most underwater robots that could be handled were large-scale robots used in deep-sea explorations. Kawamura says, "Robots that can descend more than 3,000 meters below sea level weigh in the order of hundreds of kilograms or tons. Development would cost tens of billions of yen, with just one exploration costing anything from tens to hundreds of millions of yen. With this being the case, it was not possible to use robots for environmental conservation or for surveys, without great expense."

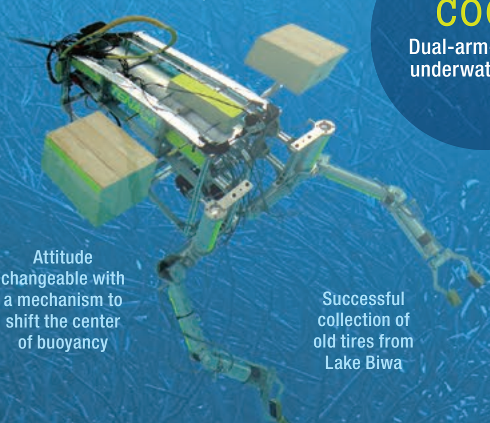
Kawamura is pursuing downsizing, weight reductions, and usability, as the number of underwater robots with such features is limited compared to actual need. "As such development is difficult, and with a lack of researchers available, neither technological nor human resource development could attain an advancement," he says, while showing his determination to take on such a difficult challenge. "I want to break up this vicious cycle."

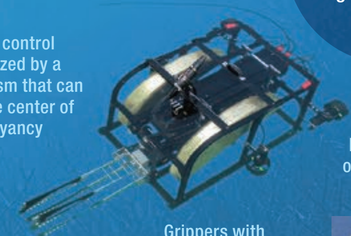
In addition to robots that are useful for environmental conservation such as COCO and ARTEMI, Kawamura is working hard on the development of a robot for the investigation of Lake Biwa's environment and also for archaeological surveys. MITSURUGI is an underwater robot that can collect samples of silt accumulated over the course of hundreds of years by sticking a thin, long cylinder of about one meter into the bottom of the lake. To minimize the effect on streams and to efficiently change directions and perform movements, he made contrivances to the variable shape mechanisms and thruster (propeller) arrangements.

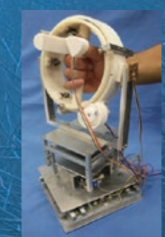
MIKAN was developed to conduct a survey of the Tsuzura Ozaki underwater site in Lake Biwa. MIKAN can dive 70 meters below the water level, where GPS signals cannot reach, and can search for earthenware at the bottom using a high-vision camera that can look for various objects, using 3D and ultrasonic signals. To enable the robot to move through areas with heavy current, it has eight thrusters and is equipped with a function to blow away surface silt using a water jet so that any earthenware buried under the silt is not damaged.

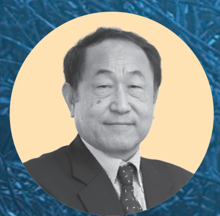
The underwater robots developed by Kawamura not only play a part in the environmental conservation activities of Lake Biwa but also support historical discoveries that can clarify geological and human history.

The integration of control and mechanisms is essential for properly operating robots underwater.









Sadao Kawamura

Professor, College of Science and Engineering

Subjects of research: Robot development for underwater operations, the design and development of soft robots, and the development of next-generation industrial robots

Research keywords: Intelligent mechanics and machine systems

Soft Robots Capable of Picking up Food Items and Placing Them inside a Lunchbox

Shinichi Hirai (left)

Professor, College of Science and Engineering

Subjects of research: Soft hands, soft object manipulation, tactile sensors, biological tissue modeling, aerial manipulation, micro pneumatic valves

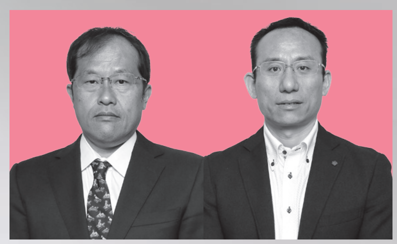
Research keywords: Intelligent mechanics and machine systems, mechanics and control engineering, system engineering

Zhongkui Wang (right)

Assistant professor, College of Science and Engineering

Subjects of research: Development of pneumatically driven soft robot grippers and the establishment of basic principles, finite element modeling, the mechanical parameter estimations of biological organs and tissues, and establishment of a training and evaluation system for senior citizens' oral care

Research keywords: Intelligent robotics, intelligent mechatronics & machine systems, biomedical engineering/biomaterial science and engineering



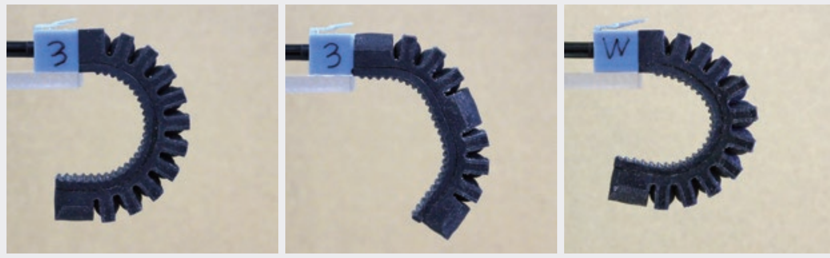
Conventionally, robots have rigid metallic bodies, moving awkwardly and not so smoothly. The development of soft robots turns this popular image of robots upside down, and soft robots are now making progress at an alarming pace.

One of the pioneers of soft robotics studies, Shinichi Hirai, has explored robotic functions different from conventional robots, by actively using soft materials. He has especially focused on developing robots that can manipulate flexible materials, capable of holding soft and deformable objects. He assumes foodstuffs as objects to be held. The target is to use robots in packaging operations at food processing plants in the near future. "The number of bento [lunchboxes] sold at convenience stores each day is about two to three million sets in Japan, with all packing done manually by human hand at factories," Hirai says, as an explanation as to why he is so devoted to this development. "On manufacturing floors, automation using robots has made substantial progress. However, robots cannot replace human workers regarding the performance of delicate tasks that require the adjustment of force for food materials of different shapes, sizes, and softness, thus not being able to finally pack such food materials. At the same time, however, in an industry where a lack of human resources is a serious issue, demand for the automatic packaging of food has certainly grown."

The first method that Hirai came up with was holding an object by surrounding it with an elastic thread and tightening it. This is a mechanism where an elastic thread is stretched around the ends of four poles resembling fingers, with an object placed inside the enclosure. Then, the fingers are closed to tighten the thread, thereby picking up the object. Pressure-sensitive conductive threads for which the electric potential changes when an object comes close or makes contact are employed as elastic threads. He came up with a contrivance where in response to the hardness of an object, the gripping force is adjusted so that it could be picked up while keeping deformation to a minimum.

Hirai put jelly beans into a Pyrex container for subdividing food materials and lifted up the container with this binding hand without ever dropping any of the materials. To further strengthen gripping force, he developed a binding hand with dual elastic threads and successfully lifted up an egg using these elastic threads.

As an extension of binding hands using elastic threads, Hirai and Zhongkui Wang, studying under Hirai, are developing flexible fingers driven by air pressure. The gripping section made of rubber and other soft materials has a shape with bellows-like indentations on one side. When air flows inside, the joint sections inflate and bend like fingers. Three of the flexible fingers are mounted onto a pneumatic control system to pick up various objects.



Thanks to the emergence of 3D printers, the production of robotic hands featuring a wide variety of designs has become possible. The shape of air chambers and material properties can control how these fingers bent.

Though the concept of this driving principle already existed, Hirai and Wang employed a 3D printer to fabricate the flexible fingers, as a means to enhance fabrication efficiency and motion reproducibility. "In conventional casting process, rubber material was manually poured into molds for casting. Therefore, the individual differences in elasticity of flexible fingers are significant. In addition, manual process induced deformation nonlinearity made finger control difficult. Instead, by using a 3D printer, we have been able to stably produce flexible fingers with nearly the same shape and elasticity," according to Wang.

In addition, taking advantage of 3D printing technology, flexible fingers can now be made, using multiple materials with different properties. First, the foundation of the finger was laminated with rigid materials. Then, it was laminated with more flexible materials. In this way, flexible fingers were formed with multiple different materials, thereby enabling the fingers to hold differently shaped objects between them. "When we carried out a gripping test on food materials, we were able to lift objects of different shapes, forms, weights, and softness, such as fried chicken, an egg, a slice of grilled salmon, and even an empty can, without deforming or crushing any of them."

The next challenge is to support the variation of food materials assuming that a packaging line at factory. The shapes and sizes of fried chicken are all different, and in addition, they may not be placed in the same position on the production line. "We need to sense these variations and link them with the motions of the robot's hands and a control of gripping power. To achieve this goal, we are considering collaboration using technologies from other fields, such as image sensing, for example."

"When I first created a robot by taking advantage of deformations such as shrinking or inflation, most people criticized soft robotics," Hirai says in reflection. In 2014, after almost 20 years, *Soft Robotics*, a special magazine covering soft robotics, was launched in the U.S. Research into soft robotics is making steady progress all over the world. He joyously relates, "Looking at what nobody else has noticed and discovering new things before others is the most interesting aspect for me."

Robots made of soft materials will be able to realize unprecedented functions.

Measuring Sleeping States Using Only Videos of Sleeping People

There are many instruments available for testing human biology, from testing equipment for diagnosing a person's physical condition to diagnosis equipment at medical institutions for discovering the presence of disease. In the development of such sensing technologies, it is said that how measurements are taken has, in addition to what to measure exactly, become important in terms of the consideration of the subject. Under such circumstances, Shima Okada, who studies sensing technology focusing on measuring sleep, has developed a non-restrictive and non-invasive sleep evaluation technique using only human bodily motion, thus surprising a number of experts in the field.

"Sleeping is very closely related to human health. From its quality and quantity, we can surmise many things, such as the state of health, mental state, and the presence or absence of various diseases," Okada explains. A mainstream sleep measurement is known as polysomnography, in which many sensors are attached to the body, continuously recording brainwaves, electrocardiograms, eye movements, electromyograms, and the saturation degree of blood oxygen, etc. Such measurements using many sensors attached to different body parts impose major burden on the subject, as they must also visit special institutions equipped with test devices to conduct measurements.

At the same time, Okada's ideas involve taking videos of the subject while asleep so as to estimate sleep depth and state of health. "The human brain works 24 hours a day, and in response to external stimulus, it constantly moves the body. While asleep, this appears directly," according to Okada. Humans gradually sleep deeper by repeating a cycle of light REM sleep and deep non-REM sleep. The deeper the sleep becomes, the less the number and times of body movement, and ultimately there is rarely any movement. Okada paid attention to this relationship between the depth of sleep and body movements, and established a method for sleep depth estimation.

Firstly, a subject asleep is monitored using a webcam with an infrared function, as body movements are measured from the image. From this data, Okada calculates various parameters such as body movement amount, continuous time of body movement, and continuous time of non-movement. Through difference processing, she created an algorithm to estimate the four stages of sleep depth (Light Sleep, Deep Sleep, REM, and Awake). In experiments to actually estimate sleep depth, the percentage of correct answers reached about 80 to 90%, demonstrating a performance that compares to existing polysomnography.

Measuring technology for sleep states can be applied to the early diagnosis of diseases and developmental disorders. As part of these efforts, and in conjunction with the department of pediatrics at Osaka University Hospital, Okada is engaged in the development of a diagnosis assistance method to discover early signs of attention deficit hyperactivity disorders (ADHD). "It is known that children with ADHD tend to be affected by sleep disorders and sleep apnea syndrome (SAS) early on," Okada says. "We conducted more-detailed investigations and found that children with ADHD had an extremely high frequency of body movements during a deep sleep where body movements would normally be inhibited." Okada thus developed a system to measure the frequency of body movements extracted from videos taken during sleep and quantitatively extracted the characteristics of ADHD. Though still in the testing stage, the significance of the performance has been confirmed.

"In the case of a small male child, it is difficult even for doctors to diagnose if he is simply energetic or has ADHD. Parents of course tend to hesitate about suspecting ADHD and thus consult with a specialist institution," Okada says. "If all they have to do is use a video camera to discover symptoms of ADHD, they would be more at ease to have their children tested. Needless to say, early diagnosis contributes to treatment and easier child-rearing later on."

Okada is now focusing on a new attempt to measure the speed of growth in a premature baby in terms of sleep. Premature babies are put into incubators at neonatal intensive care units (NICUs) and are looked after around-the-clock until they become able to breathe on their own or drink milk. "It is said that experienced nurses can judge if a baby is sleeping well and developing normally, based on slight body movement noises superimposed on the line of an electrocardiogram and from the sounds of the respirator attached to the baby," Okada explains. "We are building a method to estimate the degree of development through the movements of a premature baby by mounting a camera on incubators so as to act as the eyes of a nurse."

Discovering signs of disease or illness early on with non-restrictive or non-invasive sensing

Okada receives an endless number of requests from medical personnel to work with her. She is also developing a system to judge the presence and extent of symptoms by video-shooting involuntary movements characterizing Parkinson's disease, Huntington's disease, and other diseases that affect the nervous system, along with a system to discover diseases and dementia in the elderly at an early stage by measuring minute changes such as any instability of the body or the dragging of the feet and a system to monitor for signs of depression and dementia by sensing facial expressions. Commercialization is expected to take place very quickly.

Shima Okada

Associate professor, College of Science and Engineering

Subjects of research: Examinations of non-restrictive and non-invasive sleep evaluation techniques for children using difference images, development of new time motion study methods for medical staff, clarification of physiology functions during sleep by measuring temperature changes in bedding

Research keywords: Medical systems, applied health science, perception information processing/intelligent robotics, sensitivity informatics/soft computing

RADIANT | Ritsumeikan University Research Report | July 2017 | Issue 6 | The Future of Machines and Humans

Mechanical Eyes Providing Innovation for Flying Robots

It was a few years ago that autonomous flying intelligent helicopters or drones first emerged on the scene. Ever since, these flying robots based on multi-rotor helicopters have become very popular. Applications have extended from aerial photography to the transportation of supplies or items, with recent developments seeing a shift to flying robots for important tasks, such as at civil engineering or construction-related sites. Research involving contacting and manipulating objects while flying by mounting robotic arms and hands onto a chassis has already been reported on, but there are still many challenges in terms of commercialization. Kazuhiro Shimonomura is tackling these challenges. Shimonomura is focusing on robot vision or the faculty of sight, while also tackling the development of an aerial manipulation robot that can complete tasks while flying.

Many of the existing flying robots that do work assume that the lower part of the body is a work space so as to stably maintain the attitude of the chassis. On the contrary, Shimonomura is trying to create a robot with robotic hands on the upper part of the chassis and to extend them upward to carry out work or tasks. "By realizing such a robot, we can greatly expand the area of work done by flying robots and can also perform tasks at or investigate tunnels, indoor ceilings, or the rear-sides of bridges," he says, while explaining the great potential.

In developing a flying robot, restrictions on weight and power consumption are very severe, and this makes development very difficult. To conduct work while flying, cameras and other sensing devices, computer and control equipment controlling robotic hands and flying robots by processing acquired data, and a battery to enable work for a certain period of time are needed. However, if all of these are mounted, weight limits will be exceeded. The question is how high the performance can go with a compact and lightweight robot. That is where Shimonomura's ideas come in.

"We first built a vision system to detect objects in a state where a robot is flying and unstably shaking, and we controlled the positions of the robotic hands and integrated the processes up to moving the fingers into proper positions. We are proceeding with technological developments in terms of both hardware and software by producing devices, using a rewritable FPGA, which is an embedded processor," according to Shimonomura. In fact, he has demonstrated that by mounting a robotic hand at the top of a flying robot, it can hold a stick-like object in the sky or turn and remove a bulb from a socket.

One of the essential sensors for a robotic hand to hold an object is a contact (tactile) sensor. Shimonomura is addressing groundbreaking research to grasp this tactile sensitivity using a visual sensor. The process for a robotic hand to hold an object is comprised of exploring the object, approaching it, and holding it. Exploration requires a camera and other visual sensors, approach distance and proximity sensors, and holding tactile and pressure sensors, while data synchronization among sensors is also required. However, as described above, it is difficult to mount all of these items onto a flying robot with so many restrictions. Therefore, Shimonomura has developed a combined tactile & proximity optical sensor employing a compound-eye camera. This compound-eye camera simultaneously performs contact and proximity sensing to obtain high-resolution contact information so that robotic hand hold control is realized.

"Cameras and other visual sensors feature many measurement points. It can be said there is no other tactile sensor for which performance is so good," Shimonomura declares. Traditionally, the amount of calculations for image processing was so vast that it posed issues with calculation speeds and computer capacity, but Shimonomura has solved these issues by building an optimal control algorithm and utilizing built-in FPGA. During demonstration tests, it was confirmed that a robotic hand using only a combined sensor could hold objects of different materials such as rubber, wood, or metal. In the near future, he will enable it to hold more-softer substances such as food.

To acquire visual technology with higher performance, Shimonomura is also working on the study of robotic heads. "Human beings can clearly grasp objects even while walking when their heads are shaking up and down. I want to control the stabilization in a robot's line of sight by imitating human neck and eye movements," Shimonomura says. He realized a motion control to always keep the target by turning both eyes (cameras) and the head using image information from two cameras serving as eyes and a head angle and speed information measured by an inertial sensor (gyro sensor). All of these technologies will be applied to cameras mounted on a flying robot.

"My ultimate target is full automation in a flying robot so as to enable the conduct of various tasks," Shimonomura says, as he shows a real sense of enthusiasm. "How closer can I get? It is such a challenging-but-great theme."

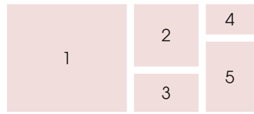
Kazuhiro Shimonomura

Associate professor, College of Science and Engineering

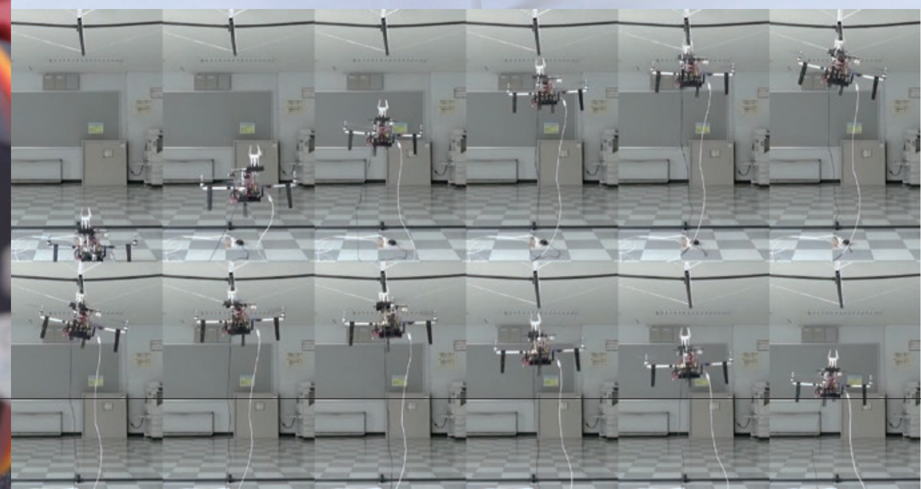
Subjects of research: Vision sensors and systems for intelligent robotic systems

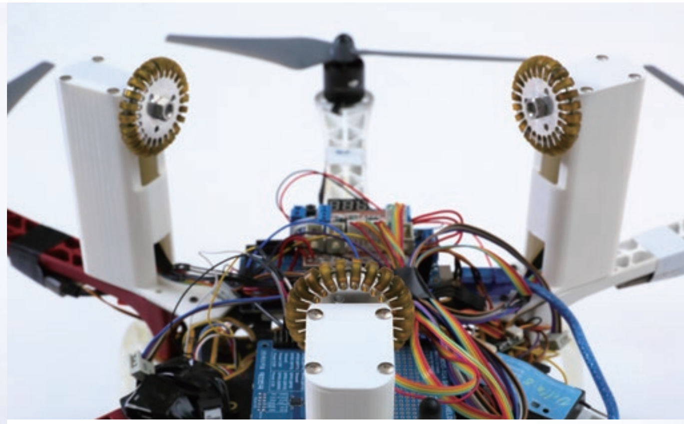
Research keywords: Perceptual information processing, intelligent robotics, electron devices/electronic equipment

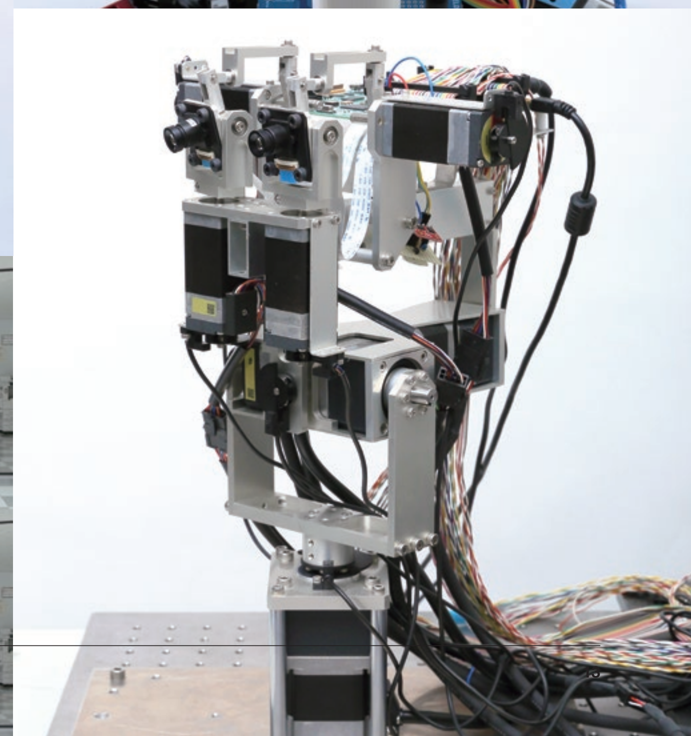
Fully utilizing visual sensors in the development of flying robots for aerial tasks



1 Visual sensor with pan/tilt mechanism mounted on a flying robot
2 Flying robot holding a stick-like object and conducting various tasks
3 Process of a robot holding a pipe on a ceiling
4 Flying robot that enables high-precision positioning by moving, while pushing wheels to the ceiling
5 Robot head







Possibilities of Intelligent Vehicles Independently Running and Carrying out Tasks in Place of People

Approaches disaster-stricken sites from the sky that are otherwise difficult to reach, using a stereo camera to generate a 3D model (photo: bottom right). By quickly understanding site conditions and providing information, rescue within 72 hours from a disaster area is possible.

What should be seen by sensor? How should it be controlled with the collected data? The accumulation of know-how and technology resulted in platooning at a speed of 80 km per hour with an inter-vehicular distance of just four meters.

Development of practical robotic technologies that can solve the many difficult problems regarding the aging of human resources involved in agriculture in Japan, from cabbage fields to orchards, and from mowing to harvesting.

Total consideration via cognition by AI to mechanical control to create innovation

Automobiles automatically traveling on roads safely and comfortably without being driven by humans, but taking people to their destinations - With current advances in AI, such automated driving is becoming true. Competition for technological development is severe, with well-known automobile manufacturers from around the world competing ruthlessly. However, for full automated driving, further breakthroughs are required.

"Just pursuing AI technology has limits," says Takanori Fukao, studying a wide range of intelligent vehicle systems, from self-driving cars to blimp robots and automated agricultural vehicles. "We cannot create innovation unless giving full consideration to AI technologies as related to the perception, assessment, and sensing of surrounding environments, as well as motion control and other mechanical aspects of automobiles, plus actuator and power control."

In cutting-edge research domains where specialist fields are becoming increasingly fractionalized, Fukao is well versed in a diverse range of knowledge and technologies in different academic domains, such as AI, computer vision, machine control, and system integration. He is in fact capable of integrating these toward the resolution of various issues, which is his main strength.

One such achievement is the development of platooning technology for automated driving. Germany is the world leader in automated automobile driving technology, and has produced an example of platooning with an inter-vehicular distance of 10 meters, but in a joint development project with the government and corporations, Fukao achieved platooning for self-driving trucks running at 80 km per hour with an inter-vehicular distance of just four meters.

"We successfully built an algorithm that can take advantage of both robotics and vehicle dynamics, and based on control design, we were able to stably maintain inter-vehicular distance with high precision," Fukao says. "We also made a mathematical model of human eyes and driving mechanisms to integrate automobile measuring with control. In addition, we studied the installation positions of vehicle-mounted cameras for sensing, along with measuring points." By combining various models from cognitive to dynamic models such as machines and actuators, he has come close to smooth automatic steering and platooning that is safe, precise, and very close to human driving. He has already finished running tests on public roads, in addition to adverse environments such as strong wind & rain conditions. A certain automobile manufacturer is currently working on commercialization.

Fukao also has many achievements regarding the study of blimp robots. One of these is the development of unmanned disaster monitoring systems. He has created a technology that can take photographs of the ground with rotating cameras while the robot is automatically flying in the sky, so as to acquire 3D information and create detailed 3D maps that cannot be obtained from artificial satellite images.

The next thing Fukao turned his attention to was the robotization of agricultural vehicles. "Labor shortages due to the decrease in the number of farmers and the aging of society are becoming more and more serious in Japan," according to Fukao. "Young people do not want to take up agriculture, as it doesn't pay well in spite of the labor involved." He considers that agricultural robots could help solve such issues. At large-scale farms overseas, the automation of large tractors has already made progress, while unmanned tractors contribute to labor-saving and efficiency promotion in farm work. However, these automatic tractors are so large and expensive that it is difficult to introduce them into Japanese agriculture. Fukao thus jointly developed with a company an ultra-compact-sized and high-precision special sensor to enable tractors to identify their locations, making drastic cost reductions possible.

Fukao is currently focusing on the development of vehicle robots for harvesting and transportation. He is now making strenuous efforts in the development of automatic harvesters for cabbage, onions, and other vegetables. "It is difficult to reproduce human expertise with machines. When a person operates a harvester, he will grab the root of a cabbage depending on a subtle sense of fingertips and will perform the harvest with delicate manipulation. To reproduce this delicate manipulation based on experience and sense with a machine, we need to understand where we should sense and how such should be communicated, in order to control the mechanisms. In other words, the work process from perception to motion is considered as a continuous value, and it needs to be linked to steering. How should we combine sensing, control, and driving so as to build an optimal system? Finding a solution is most interesting," Fukao says.

In addition, he is recently working on the development of an automatic machine that can move freely within an orchard and that performs fully unmanned mowing, agrochemical spraying, and harvesting. Here again, he is tackling difficult problems such as steering technology to move across uneven ground and among fruit trees standing close to each other without crashing into them or falling over, along with a reproduction of "human skills" that can smoothly and speedily pick fruit with the machine. "I am aiming to commercialize this technology within five years," Fukao says. A future where intelligent robots take care of agriculture in place of people is getting closer.

Takanori Fukao

Professor, College of Science and Engineering

Subjects of research: Automated driving, platooning and parking of automobiles, flight control of blimp robots and drones, automated driving of agricultural vehicles, active control (including active suspension systems), 3D model generation by motion stereo or stereo camera

Research keywords: Perceptual information processing, intelligent robotics, dynamics/control, intelligent mechanics/mechanical systems, control engineering/system engineering, aerospace engineering, agricultural environmental engineering/agricultural information engineering

Cloud Computing and AI: Changing the Business Landscape

"With the arrival of cloud computing, which refers to sharing of computing resources over networks and also artificial intelligence (AI), the shape of business is now being changed completely."

Yuichi Yoda is currently studying the influence of such innovation in information technology on the marketing practices and information system developments of corporations. "AI, which is currently mainstream, can acquire new recognition out of vast amounts of data, which people cannot handle themselves, all through deep learning. Deep learning is a new machine learning method that can create feature value independently based on the data itself. This is in addition to machine learning, which identifies hidden patterns and regularity out of the collected data," Yoda explains. The current level of AI has become possible due to the capabilities of storing and processing huge amounts of data available from the computer's enhanced processing capabilities and speed of a computer, in addition to cloud computing.

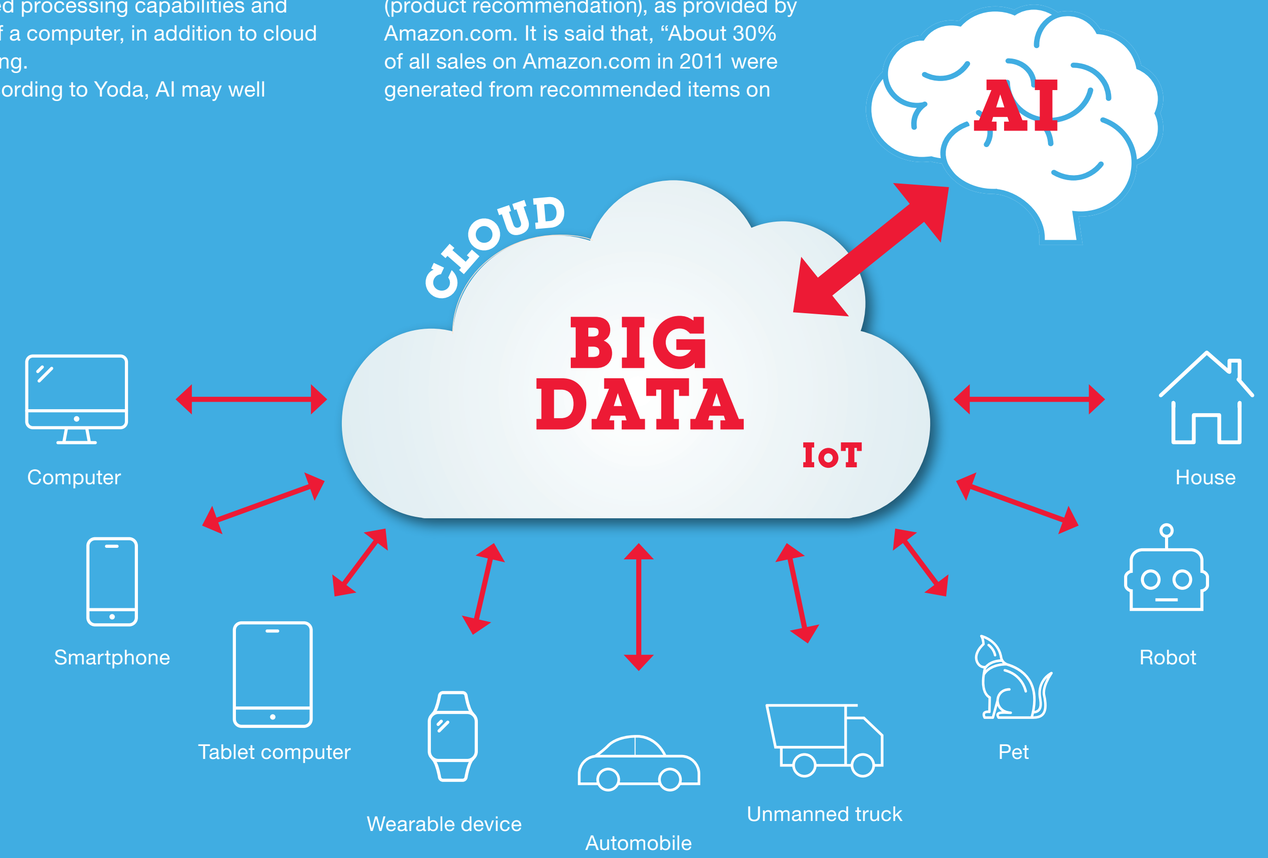
According to Yoda, AI may well change the corporate marketing practices greatly, especially the customer value creation processes. It may be completely different from the way things were beforehand.

"With traditional marketing research, consumer needs were surveyed through questionnaires and experimentation, which provided reasons that determined customer need."

At the same time, the process in which AI can discover customer need in actual commercial environments such as in internet-related business is significantly different. For example, marketing at internet-related business sites utilizing AI does not probe customer need based on reasoning, as illustrated above. It pays attention to results, such as product browsing and purchasing patterns. Herein lies the main characteristic of machine learning, which learns from mass data in the form of results. One good example of this is the recommendation function (product recommendation), as provided by Amazon.com. It is said that, "About 30% of all sales on Amazon.com in 2011 were generated from recommended items on this information system."

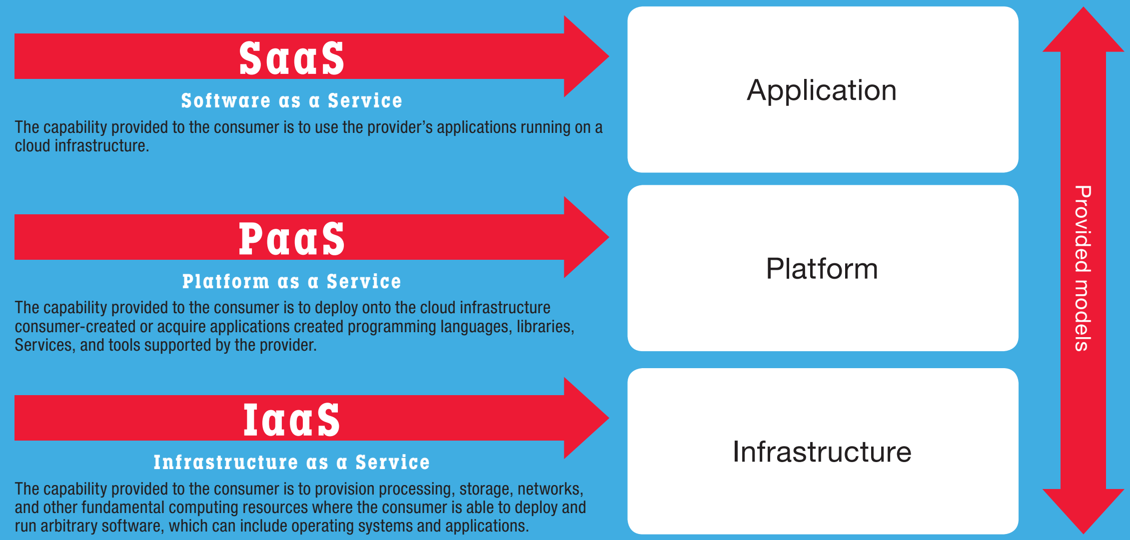
In addition, Google has already applied deep learning to more than 20 of its actual services. It is also applied to Google's major service, i.e., Searching and Search advertising. As one of the key signals (elements) in the ranking of search results, RankBrain by deep learning has been introduced. In particular, relatively new search queries have shown the effects of the introduction of RankBrain. Google tries to understand what AI is actually doing as according to the characteristics of deep learning, which has become a black box (Yoda et al. 2016).

"We can see the effectiveness of a practical method to try and adjust to customer's need based on the results acquired in the actual commercial environments that customers are dynamically involved in," Yoda says.



Cloud Service Models

The services utilizing cloud computing can be largely categorized into three models.*



*Reference: National Institute of Standards and Technology (NIST) service models

Effectiveness of PaaS

Concentrating Resources for High Value-Added Application Development

Main tasks of system construction	Conventional software development	Conventional software development
Environmental procurement/construction (hardware, middleware, network)	●	Labor reduction
Release management (management, release application)	●	Labor reduction
System environment maintenance (back-up, security, hardware)	●	Labor reduction
Capacity management (performance, volume addition)	●	Labor reduction
Software maintenance (version upgrade, security)	●	Labor reduction
Development environment preparation (hardware, middleware, network, development tool)	●	Labor reduction
Application development (functional development)	●	◎

Radical review of the roles of humans and AI in business

On the other hand, Yoda points out that cloud computing and AI have caused a paradigm shift not only for companies using information systems but also their providers. One of these is the utilization of the cloud service, Platform as a Service (PaaS). "PaaS is a service provided by a service provider as an application development environment and a provision environment on a cloud," according to Yoda.

Previously, many companies had their own servers and other infrastructures, developed necessary applications, and built original information systems. However, by using PaaS, companies building an information system can utilize standard components of sophisticated software provided by PaaS and concentrate upon the development of applications tailored for their own objectives and needs. As cloud service providers bear the responsibility of maintenance and the management of information systems, system engineers (SEs) do not need to take care of maintenance and service issues, thus, resulting in a drastic cost reduction.

Recently, in addition to Business Intelligence (BI) tools and other data analysis services, machine learning and deep learning have been implemented in PaaS. As a result, user companies independently apply services with improved performance compared to conventional services, which may result in the re-assessment of service providers regarding the development, service, and maintenance of information systems, along with the re-assessment of IT consultants and SEs. For example, "These people will be required to play roles that only humans can carry out like problem setting so as to fully maximize the effectiveness of AI and data storage designs," Yoda says. "Humans and AI can supplement each other by focusing on the strengths unique to humans that AI cannot handle, such as the capability to make assumptions with a limited amount of experience data, the ability and insight to understand context as endorsed by social and cultural experiences, the ability to establish questions, an aesthetic sense, and an understanding of sentiments." In the world of business, how people could effectively complement each other is a current area of research. From now on, we should take into consideration how AI integrates into the business world.

Yuichi Yoda

Associate professor, College of Business Administration

Subjects of research: A Research of Corporate Information Systems Management through Business Transformation: Flexibility and Strategic Extensibility of Information System, Corporate Information System Development utilizing Cloud Services: Through Platform as a Service(including Cloud AI), Philosophy-based management in corporate transformation

Research keywords: Business model, Information systems management, Cloud service, PaaS, AI, Business transformation, Philosophy-based management

Chairs, Designed by AI with Its “Imagination”

AI learns a “style” through big data.

It was 2015 when an amazing technique was demonstrated in a paper, which turns any photograph or picture into a piece like Picasso or van Gogh. We can now enjoy such an application on a smartphone.

Ikuko Nishikawa, studying machine learning and optimization, is one of the researchers interested in this “painting style transfer” by a convolutional neural network. In particular, she focuses on working with corporations and designers to apply this style transfer to some practical use.

Firstly, a neural network is a computing model simulating a biological neural network of the brain. In addition to tremendous improvement of the computer performance in processing time and resources, the availability of a huge amount of data on the internet has accelerated the recent development of this computing model. Deep neural networks obtained by learning a huge amount of data play a key role in the present artificial intelligence (AI).

She explains the learning mechanism as follows. A neural network is designed to change its structure until it acquires the desired ability, for example, a desired classification of the given image data. To recognize a cat on an image, a large amount of image data is input to it, and only when there is a cat, it is demanded to answer so correctly. If the answer is incorrect, the network is slightly modified, in a direction not to make the same mistake when the same image is shown the next time. Simply repeat this over and over, without any hint on any feature of the cat. In parallel, the same procedures are run for other objects to be recognized. The initial network can only answer randomly. By the modification as a feedback to a wrong answer, it begins to discover the hints to classify the images correctly, based only on whether the answer is correct or not. After repeating this trial-and-error processes, the network gradually finds effective hints such as the presence of a certain shape or color as a key element for classification into a cat and other classes. Taking a shape as an example, it starts with the simplest element, a line segment. Next, the network combines simple elements into slightly more complex figures and coloring. In a layered network, the process to extract elements (filtering, or convolution) is repeated on every single layer, and by combining them, the network gradually extracts more abstract objects as faces and coats of hair. And it ultimately identifies whether a given image possesses the enough characteristics of a cat, which leads to the answer.

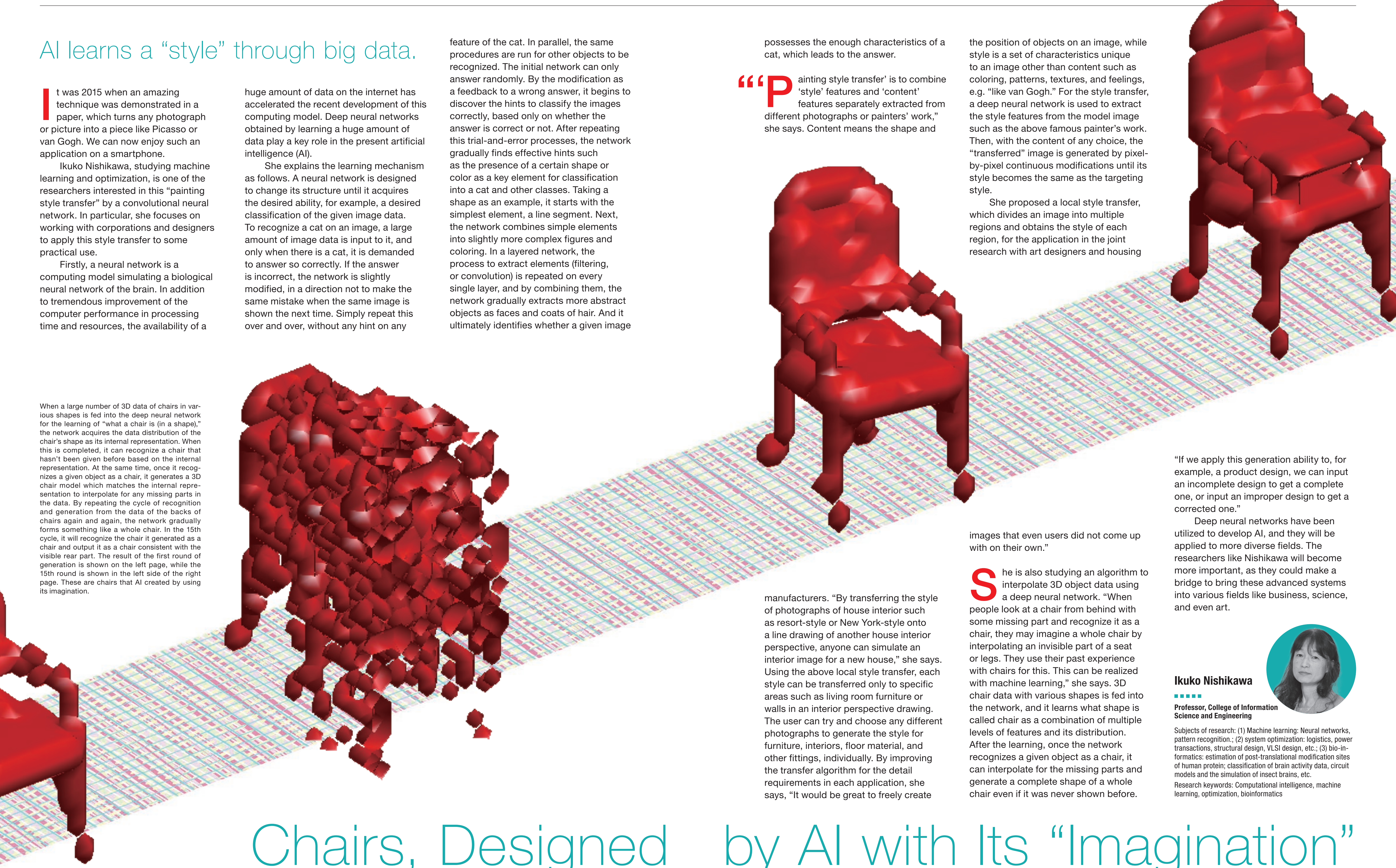
“‘Painting style transfer’ is to combine ‘style’ features and ‘content’ features separately extracted from different photographs or painters’ work,” she says. Content means the shape and the position of objects on an image, while style is a set of characteristics unique to an image other than content such as coloring, patterns, textures, and feelings, e.g. “like van Gogh.” For the style transfer, a deep neural network is used to extract the style features from the model image such as the above famous painter’s work. Then, with the content of any choice, the “transferred” image is generated by pixel-by-pixel continuous modifications until its style becomes the same as the targeting style.

She proposed a local style transfer, which divides an image into multiple regions and obtains the style of each region, for the application in the joint research with art designers and housing manufacturers. “By transferring the style of photographs of house interior such as resort-style or New York-style onto a line drawing of another house interior perspective, anyone can simulate an interior image for a new house,” she says. Using the above local style transfer, each style can be transferred only to specific areas such as living room furniture or walls in an interior perspective drawing. The user can try and choose any different photographs to generate the style for furniture, interiors, floor material, and other fittings, individually. By improving the transfer algorithm for the detail requirements in each application, she says, “It would be great to freely create images that even users did not come up with on their own.”

She is also studying an algorithm to interpolate 3D object data using a deep neural network. “When people look at a chair from behind with some missing part and recognize it as a chair, they may imagine a whole chair by interpolating an invisible part of a seat or legs. They use their past experience with chairs for this. This can be realized with machine learning,” she says. 3D chair data with various shapes is fed into the network, and it learns what shape is called chair as a combination of multiple levels of features and its distribution. After the learning, once the network recognizes a given object as a chair, it can interpolate for the missing parts and generate a complete shape of a whole chair even if it was never shown before.

“If we apply this generation ability to, for example, a product design, we can input an incomplete design to get a complete one, or input an improper design to get a corrected one.”

Deep neural networks have been utilized to develop AI, and they will be applied to more diverse fields. The researchers like Nishikawa will become more important, as they could make a bridge to bring these advanced systems into various fields like business, science, and even art.



When a large number of 3D data of chairs in various shapes is fed into the deep neural network for the learning of “what a chair is (in a shape),” the network acquires the data distribution of the chair’s shape as its internal representation. When this is completed, it can recognize a chair that hasn’t been given before based on the internal representation. At the same time, once it recognizes a given object as a chair, it generates a 3D chair model which matches the internal representation to interpolate for any missing parts in the data. By repeating the cycle of recognition and generation from the data of the backs of chairs again and again, the network gradually forms something like a whole chair. In the 15th cycle, it will recognize the chair it generated as a chair and output it as a chair consistent with the visible rear part. The result of the first round of generation is shown on the left page, while the 15th round is shown in the left side of the right page. These are chairs that AI created by using its imagination.

Ikuko Nishikawa

Professor, College of Information Science and Engineering

Subjects of research: (1) Machine learning: Neural networks, pattern recognition.; (2) system optimization: logistics, power transactions, structural design, VLSI design, etc.; (3) bio-informatics: estimation of post-translational modification sites of human protein; classification of brain activity data, circuit models and the simulation of insect brains, etc.

Research keywords: Computational intelligence, machine learning, optimization, bioinformatics

Exploring the Nature of Human Senses and Perception in the Evolution of Video Games

To what degree can robots perceive and understand the world, and how can they become able to think and act like human beings? "Ways that artificial intelligence (AI) technology can solve these ultimate challenges may be found in a familiar form of entertainment such as video games," Hiroshi Yoshida says, as he presents a unique viewpoint. "Video games emerged in the 1980s and quickly became popular around the world, causing a transformation in our perception and senses, which may well be the foundation of today's computer society," according to Yoshida, shedding new light on the development of AI technology, from the viewpoint of aesthetics.

Yoshida states that aesthetics is an academic field analyzing human senses and perception. The English term "aesthetics" has been translated as *bigaku* (study of beauty) in Japanese. It has dealt mainly with art and beauty as subjects of study. Yoshida, on the contrary, redefines aesthetics as a field dealing with every kind of sensory perception, which was its original meaning, and he studies video games as one of the most suitable research subjects. He says that there are many links and overlaps between aesthetics, which elucidates the logic of sensory or intuitive thought and judgement, and the study of video games, which clarifies players' perception, recognition, thought, judgement, and actions through interaction.

"From the viewpoint of aesthetics, the experience of playing a video game can be defined as a doubling of perception," Yoshida explains. "When playing a video game, we visually recognize images drawn by a group of square dots on a screen as *icons* that refer to people and things in the real world. However, these images are also perceived as *objects* depicted by program codes and processed mechanically. Players of video games thus perceive in-game images such as that of Mario to be *icons* and *objects* simultaneously. Using the terms of semiotics, the doubling of the semantical and syntactical dimensions is at work at all times. This doubling of perception is the essential moment of playing video games."

Super Mario Bros
(Nintendo, Family Computer, 1985)

While playing *Super Mario Bros.*, for instance, players see the image of the protagonist, Mario, as *icon* (resemblance of a person) and as *object* (target of manipulation). In other words, players simultaneously perceive semantical and syntactical processes on the one screen.

Furthermore, from an aesthetic standpoint, video games in the 1980s or earlier, which were technologically immature, are being rediscovered as something that effectively utilizes the properties of human senses and perception including visual illusions "This is where we may find the keys in the evolution of computer technology and virtual reality (VR)," Yoshida suggests. An example would be scrolling techniques—one of the most basic constitutive principles of video games.

Scrolling is a technology causing an illusion in that moving the monitor (TV) screen in four directions (up, down, left, and right) gives the illusion that spaces continuously extend beyond the frame of screen. "This scrolling technology, now integrated into many computer software programs as well as games, was created for car racing games in the late 1970s," Yoshida explains. *Monaco GP* (Sega, 1979) was one of the earliest video games that could afford an illusionary effect as if the car being operated by a player was moving forward by moving the background in the form of other cars and roads from the top of the screen to the bottom. In *Night Driver* (Atari, 1976), a few white objects were moved on a black background to afford an illusion of motion as if the car being driven was moving forward. "Unlike modern video games, simpler ancient video games made full use of the characteristics of human perception to express the senses of space and motion," Yoshida says. "There, we can still find amazing ideas and ingenuity."

Yoshida also paid attention to the visual expression method of the so-called, quasi-3D games, prior to the introduction of 3D computer graphic technology (such as polygons). In particular, a study of the parallax effect, which causes an illusion in depth by the parallax, is very interesting. "In *Moon Patrol* (Irem, 1982), which first introduced this parallax effect, space was constituted by three layers of different colors of brown (ground), green (hills), and blue (mountains). As these three layers scrolled at different speeds, the eyes of the player see things as if there was depth in the game space." Yoshida says this method was possibly introduced into video games via Walt Disney animation films. Technically, it was incomparable to modern high-definition 3D images, but based on a proper understanding of the mechanism of human perception, it could sufficiently realize the purpose of expressing 3D spaces and objects. Such technologies were already in stock by the 1980s before the arrival of Super Famicom (Super Nintendo Entertainment System, 1990) and PlayStation (1994).

Yoshida inquires further: "Can we consider the evolution of machine technology as that of video games as such?" "Hasn't possibly the technological evolution suppressed or degenerated the human imagination? Isn't the same perspective applicable to the latest technological developments of AI?" With bright eyes, he says, "It is interesting that, by deciphering the ideas and ingenuity found in classical video games, we can find a path toward designing new AI."

The "transformation of the senses" as brought about by video games in and after the 1980s laid the foundation for today's computer society.

Hiroshi Yoshida

Professor, Graduate School of Core Ethics and Frontier Sciences

Subjects of research: Aesthetics and Philosophy of the Senses, Play and Game

Research keywords: Aesthetics, Ludology, Game Studies

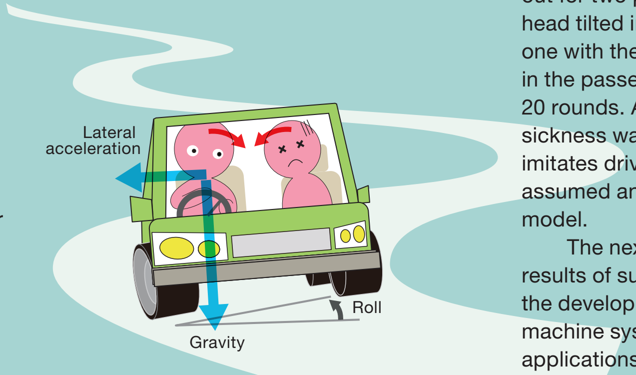
Defining Comfortable Driving by Understanding Human-Machine Matching

Thanks to the emergence of driving assistance systems such as collision avoidance systems, which can detect obstacles, automatically apply the brakes, and avoid collisions, safety in driving has been drastically improved. Intelligent machine systems that can physically interact with people are known as human-machine systems. Takahiro Wada pays attention to this coordination between people and machine systems, as he explores comfortable and easy-to-use machine systems.

"For example, while considering the realization of comfortable driving, what came to mind was the question: What is comfort in the first place?" says Wada, trying to numerically express the comfort that humans feel. As part of these efforts, he created a mathematical model to estimate the extent of car sickness.

"In addition to visual, auditory, tactile, and other sensory organs, humans possess a vestibular sensation, or a sensor to capture the movements of the body (head)," Wada explains. "This includes otoliths in the ears to sense directions of right, left, forward, and backward, in addition to tilts, and semicircular canals capturing rotating movements." That is to say, people maintain balance by sensing body movements using acceleration and gyro (angular velocity) sensors in the body and by integrating information from them with other sensory information such as visual information, as a means to control movement.

The sensory conflict theory, which postulates that motion sickness or car sickness occurs by accumulation of differences between information from sensory organs and their estimates from experience. In relation to this, there is also a hypothesis that motion sickness or car sickness occurs when a difference is caused between a sense in the direction of gravity acquired by integrating various sensory information and a sense of the direction of gravity understood by the central nervous system based on experience. Wada successfully expresses this hypothesis, which is known as "Subject Vertical Conflict," in the form of a mathematical model based on knowledge of neuro and cognitive science (Refer to the illustration at right). He confirmed the validity of this mathematical model, saying, "The results of experimentation measuring the ratio of feeling nauseous due to vibration and the nausea probability estimated by this mathematical model of car sickness showed similar values."



Movement of driver's head when turning a curve; the natural movement of tilting the head in the same direction of the rotation of the curve prevents car sickness.

Furthermore, Wada is taking further steps forward, utilizing this mathematical model as an index to evaluate comfort in automobiles and for methods to prevent car sickness.

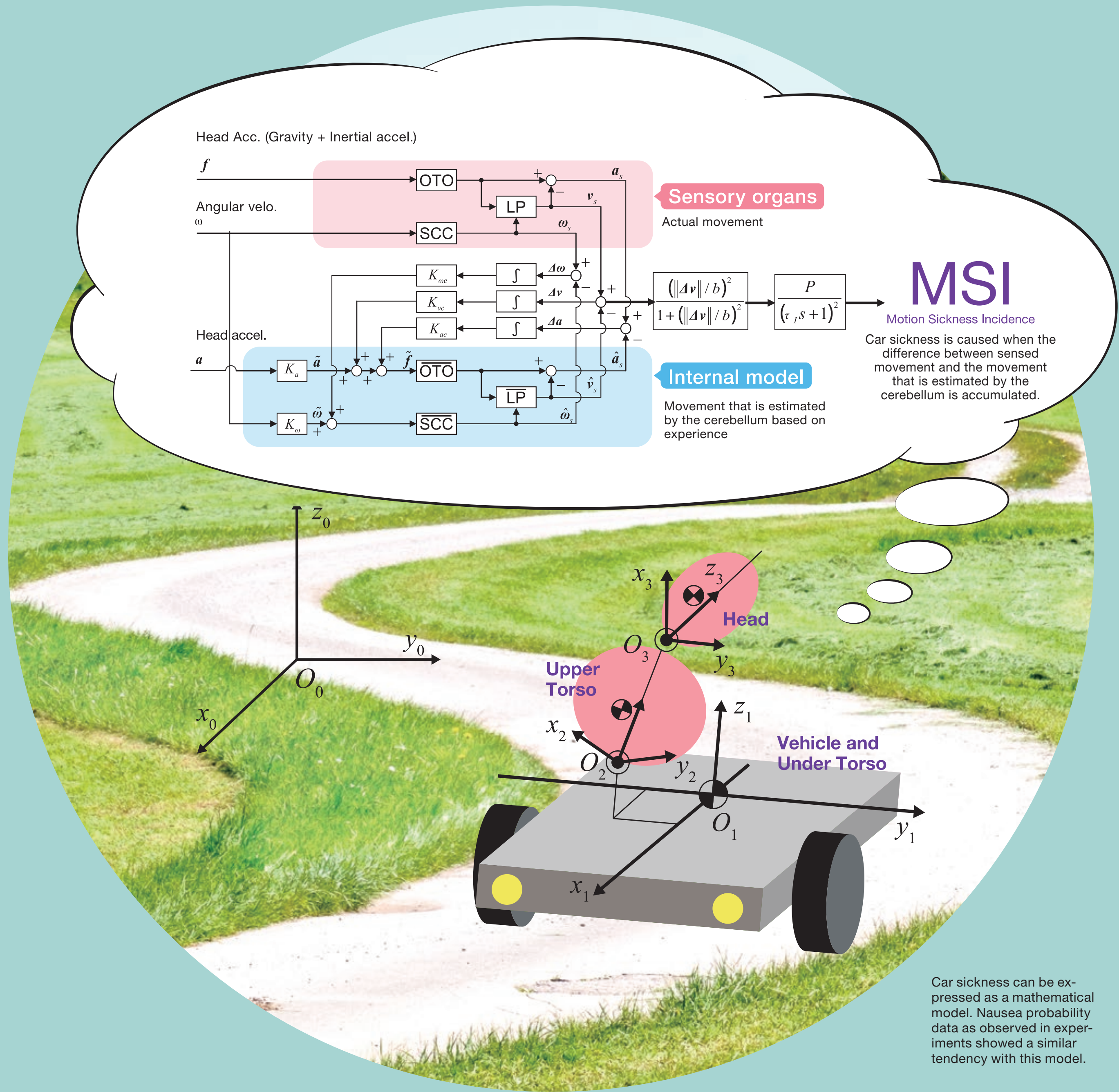
"It is often said that the person in the passenger seat tends to experience car sickness, while the driver does not. While conducting an investigation, it was found that when turning a curve, the head of the driver and that of the passenger tilt in opposite directions," according to Wada. As a car turns a curve, the driver tilts his head in the same direction of rotation, while the person in the passenger seat tilts his head in the opposite direction as if being pulled by a centrifugal force. Under an assumption that "if we can control this head movement, it might be possible to reduce car sickness," Wada measured the head movements of the driver and the person in the passenger seat during slalom traveling and inputted the results into said mathematical model, concluding that the driver's head movement reduces car sickness.

Based on this hypothesis, he conducted an experiment at a racing-cart course. Experiments were carried out for two patterns of driving, with the head tilted in the direction of rotation, and one with the head tilted like the person in the passenger seat, for a maximum of 20 rounds. As a result, a reduction in car sickness was confirmed when the person imitates driver's head movements, as assumed and as per the mathematical model.

The next step involves applying the results of such human modeling into the development of robots and human-machine systems. Wada is studying such applications of the mathematical model for car sickness in the development of, for example, a car navigation system to navigate to a destination by selecting a route that enables driving with less chance of car sickness or an automated driving system aiming for reducing the chance of such sickness. Also, the mathematical model of car sickness includes sections that estimate how humans perceive their own motion. He is now working on research into this self-motion perception, considering that it can be utilized for enhancing the comfort of machine operations, despite the fact that feelings of discomfort when being involved in such operations are characteristically less when compared to car sickness.

Wada is also interested in diverse human-machine systems such as rehabilitation robots or artificial leg systems, in addition to car driving. One of these is the formulation of a mathematical model for comfortable walking, taking advantage of inertia. Once a human starts to walk, an inertia kicks in, and though one can't suddenly stop, one can easily walk with minimum power by utilizing this inertia. Wada is attempting to develop easier-to-walk artificial leg control by making use of this.

In the development of human-machine systems, as represented by driving assistance systems, the pursuit of safety and reliability has attracted considerable attention thus far. As a certain level of performance has been sufficiently achieved, human comfort is becoming more and more important. As a true pioneer, Wada has been addressing the challenge of establishing mathematical models to quantitatively evaluate a comfort level that has so far been difficult to realize. Sooner rather than later, an innovative human-machine system that is both comfortable and easy to use may well be created.



Car sickness can be expressed as a mathematical model. Nausea probability data as observed in experiments showed a similar tendency with this model.

Establishing a mathematical model of comfortable motion and applications for human-machine systems

Takahiro Wada

Professor, College of Information Science and Engineering

Subjects of research: Aiming for the elucidation of comfort in operating robots/mechanical systems and the establishment of its application methods to the design and control of human machine sytems.. His research interests includes modeling the sensory-motor systems of humans and applications for motion control in intelligent mechanical systems, mathematical modeling of driving comfort and machine systems, human factors in automated driving, and robot control

Research keywords: Intelligent mechanical systems, human-machine systems, robotics, biological cybernetics

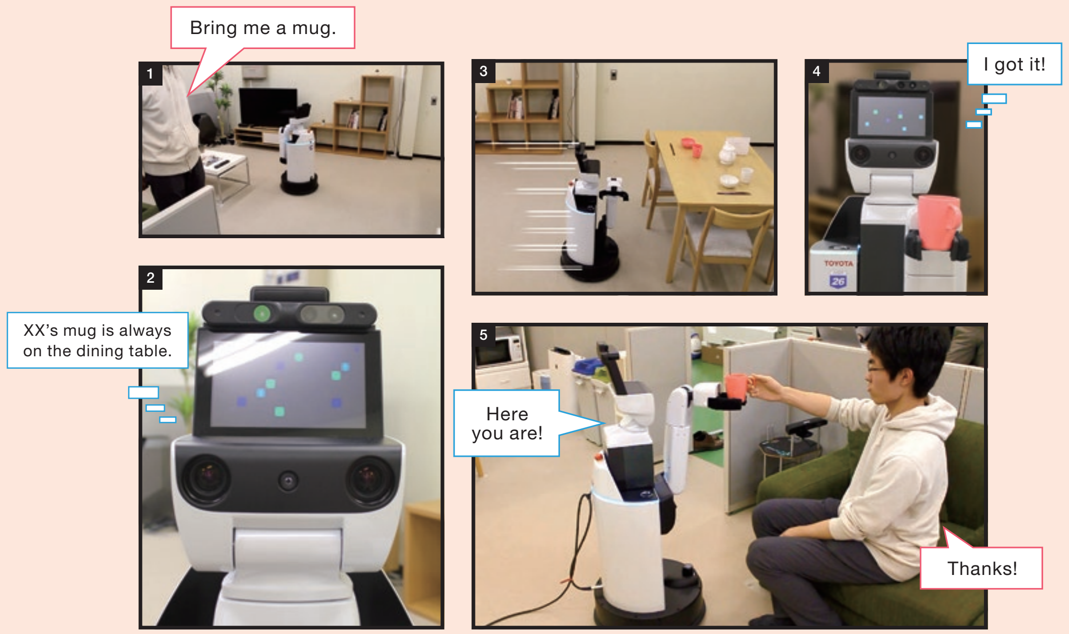
Artificial Intelligence Acquiring Vocabulary and Concepts in Ways Similar to a Child

"Bring me a glass." If asked by someone in your family at home, most people will go directly to the kitchen, open the cupboard, and, if it is for their mother, will perhaps choose the glass she prefers and bring it to her. Without any great detailed explanation, human beings can do all this simply from just one phrase. Could robots do the same?

Tadahiro Taniguchi is trying to achieve this with an approach known as "Symbol Emergence in Robotics," which is different from other common ideas. Alongside Yoshinobu Hagiwara, he is currently working on the development of a family-focused robot that can independently extend knowledge via communication with human beings.

"Each family has its own local rules and language. Taking a kitchen as an example, its location, the things in it, and how they are called differs from family to family," Hagiwara says. "We are in the process of creating a family-focused robot for individual families that can learn local rules and language from a bottom-up approach and that can support family life, as required by the situation of each family."

What will be developed is a robot that can perceive the external environment in a multi-modal manner with multiple sensing devices mounted to it, and based on information from these sensors, it can learn locations pertaining to retrieving or placing regular objects. Firstly, as sensory organs to connect with human beings and the external environment, a camera to obtain visual information, a microphone for speech recognition, and distance sensors for estimating certain locations are mounted on the robot. Then, generation process for the acquired object images, speech sounds uttered by people, and the position information of the robot itself are modeled. Finally, a method is established in which the robot assumes the parameters of the locations via Gibbs sampling, etc., and by repeating the process, the robot can acquire location concepts.



Hagiwara and his team also conduct demonstration tests while actually using robots. In an experimental family space, such as in a living room, dining room, and kitchen combined into one, containing a refrigerator, a cabinet, an oven rack, bookshelves, TV, table, sofa, and other pieces of furniture, they have a robot learn a set of vocabularies indicating 11 locations. These include "in front of the table" or "in front of the dining room," in addition to observed image information of objects, such as a glass, while moving. By repeating this process, the robot becomes able to predict correct locations from the available vocabulary at a probability of more than 70%, and can actually carry objects. "For example, for common items such as a glass or a table, the robot can set a yellow glass on the table in front of the dining room and a white glass on a large-sized table. Based on the location concept acquired through interaction and repetitions with the external environment at each family location, the robot has become able to carry each glass to a suitable location based on each family's local rules."

Towards next-generation AI with Symbol Emergence in Robotics

"The current era of AI, which is known as the third AI boom, depends on the processing capabilities of computers that can handle vast amounts of data, in addition to deep learning and other machine learning," Taniguchi explains. Regardless of how much data is collected, it will not lead to the acquisition of the above-mentioned local knowledge. In response to this, Taniguchi says, "We are aiming at an AI that can form a concept from a bottom-up approach by integrating multi-modal perceptional information acquired from communication and interactions with human beings and its environment. We want to create a next-generation AI that can acquire intelligence under a process as if a child understands the language and the environment step-by-step." Symbol Emergence Systems are the philosophical basis for this, and Taniguchi has been addressing such systems for more than a decade.

"After a person is born, we experience language or symbols via people around us and we understand the meaning of concepts and language, local context including cultures and customs, and ambiguous expressions by communicating with others and interacting with our environments," Taniguchi says. "The key point of Symbol Emergence Systems is to focus on such dynamic processes of concepts and of language acquisition." By having a design drawing of intelligence that supports human Symbol Emergence Systems or computational principles, it will be possible to create AI that is completely different from existing forms.

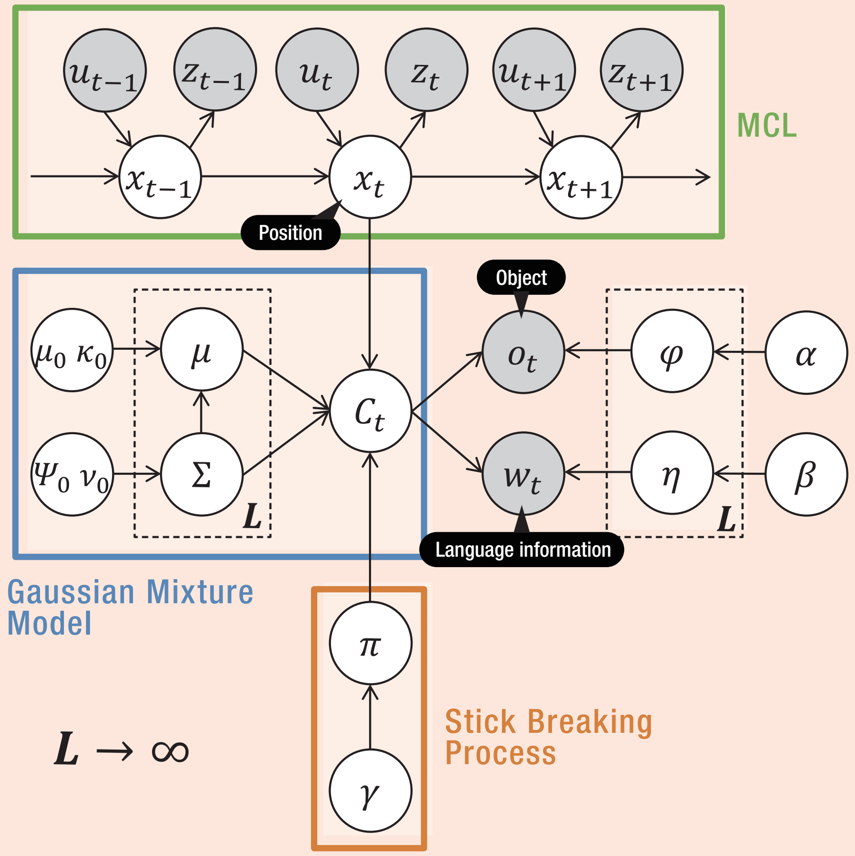
What is essential for achieving this goal is a physical body that can accumulate a multitude of experience by contacting with the external world. This involves not only building a program as a computational expression of intelligence but also creating a robot that has sensors and actuators, and interfaced to the real world. The true value of Symbol Emergence in Robotics can be found right here.

"It may sound paradoxical, but sooner or later, we may be able to improve on our understanding of human activity via robots," Taniguchi says. Through a study of Symbol Emergence Systems, he is eager to approach the essence of human activity from this perspective.

Graphical model of location concept learning

Estimating parameters based on position, objects, and language information

x_t	Self-position information of a robot
z_t	Observational information via a distance sensor
u_t	Motor control information
o_t	Object information acquired via observed images
w_t	Vocabulary information
C_t	Index of location categories
μ, Σ	Parameters of Gaussian distribution
φ, η	Parameters of multinominal distribution
π	Multinominal distribution index of location categories
$\mu_0, \kappa_0, \psi_0, \nu_0$	Hyper-parameters of Gauss-ian-Wishart prior distribution
α, β	Hyper parameters of Dirichlet prior distribution
γ	Hyper parameters of pi



Tadahiro Taniguchi (left)

Professor, College of Information Science and Engineering

Subjects of research: Constructive understanding of emergent systems involving human beings and technological applications

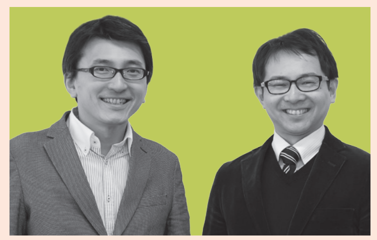
Research keywords: Statistical science, cognitive science, human interface and interaction, intelligent informatics, soft computing, intelligent robotics, Kansei informatics, intelligent mechanics/mechanical systems

Yoshinobu Hagiwara (right)

Assistant professor, College of Information Science and Engineering

Subjects of research: Location conceptual learning based on multi-modal information and applications for life support robots

Research keywords: Human interface and interaction, intelligent informatics, intelligent robotics, measurement engineering



RESEARCH TOPICS

First-ever Japanese Application of a Cross-appointment System

In conjunction with Panasonic Corporation ("Panasonic"), Ritsumeikan University has introduced a cross-appointment system,*1 for cross-organizational human resource exchanges so as to enhance industry-academia-government partnerships in AY2017. This is a first in Japan*2 involving a university faculty member working for a private company, as a result of taking advantage of this system.

On April 1, 2017, Tadahiro Taniguchi, professor at the College of Information Science and Engineering, started working at Panasonic's Business Innovation Division as a visiting general chief scientist, while also maintaining his position at the university. In terms of working arrangements, the ratio of his engagement at Panasonic will be 20%.

Through this system, Taniguchi will provide Panasonic with knowledge regarding new technologies in the rapidly expanding and highly watched fields of artificial intelligence (AI) and robotics. He will also extend assistance in planning technological strategies to create new business in these particular fields. In addition, he will be engaged in co-creation activities for the IoT/robotics fields, which Panasonic is currently focusing on, while supporting community development involving Ritsumeikan University and academics, and while tackling human resource development through working group activities on a number of relevant themes.

*1 Cross-appointment system: A system involving a faculty member's temporary transfer while maintain his/her position at a university based on interorganizational agreements with other universities, public research institutes, corporations, and other organizations. Among all the activities in education, research, social contribution, and other fields that university faculty members are engaged in, the faculty member transferred applies part of his/her activities in research to such an organization and therefore conducts research activities both at the university and at other organizations.

*2 As of March 31, 2017. Source: Survey conducted by Ritsumeikan University and Panasonic.

Art Research Center Certified as a MEXT Joint Usage/Research Center

The Art Research Center was certified as a "Joint Usage/Research Center" under the "Program to Promote the Joint Usage/Research Centers of Distinction (Functional Strengthening Support)" in AY2014. It was certified once again in April 2017.

Based on improvements made to research infrastructures over the preceding three years, this project aims to realize the "Concept of a Japanese Culture Research Space" by having research activities conducted by humanities researchers become born-digital,* as well as to establish online knowledge archives. The concept aims at targets in a semantic way by linking a large number of databases for materials and content databases for theses, etc., (knowledge databases) with each other so that all research themes on humanities researchers are made interdisciplinary beyond classifications thus circulating knowledge dynamically.

The Joint Usage/Research Centers aim to improve on a system to utilize the research potential of national, public, and private universities and to improve joint research structures by researchers, so as to advance academic research activities as a whole in Japan. A total of 105 research centers are certified (as of April 1, 2017, with 53 universities, including 28 national and 25 public/private universities, certified as Joint Usage/Research Centers). During this academic year, two cases, one of which was our Art Research Center, were certified in said program.

* The term "born-digital" refers to information recorded in a digital format at the time of creation/generation and where it is created and distributed via electronic media without any printed media being used.

Research Assistant System: Established to Support Research during Times of Major Life Events

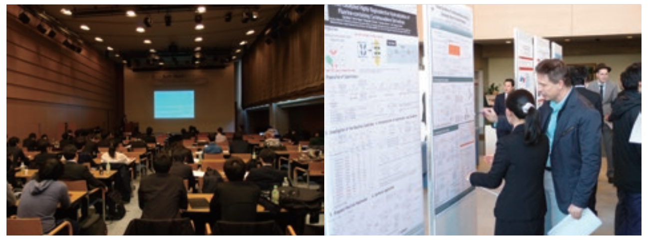
In December 2016, Ritsumeikan University established the Research-Life Support Division for Promotion of Gender Equality, which conducts a wide variety of activities, with a special focus on supporting female researchers. In April 2017, Ritsumeikan University established the Research Assistant System in order to support researchers in continuing research by deploying university and graduate school students as research assistants during times of major life events such as childbirth, child-rearing, or nursing care, when researchers do not have sufficient time to conduct research. By supporting research activities during such life events, regardless of gender, the main aim is to ensure diverse research environments.

Holding of the 6th International Symposium on Functionalization and Applications of Soft/Hard Materials (Soft/Hard 2017)

From January 20 to 22, the 6th International Symposium on Functionalization and Applications of Soft/Hard Materials (Soft/Hard 2017) was held, hosted by the Research Center for Soft/Hard Hybrid Functional Materials at the Biwako-Kusatsu Campus.

Certified as a "MEXT Supported Program for the Strategic Research Foundation at Private Universities" (AY2012), the Research Center for Soft/Hard Hybrid Functional Materials has been engaged in the research & development of novel materials. Through this effort, completely new functions and performance that cannot be manifested via single molecules can emerge, by using functional materials and hierarchically controlled structures that make contradicting elements of high performance and high strength compatible, based on the unique concept of hierarchically controlled structures. This R&D initiative featured the collaborative efforts of researchers involved in soft materials (applied chemistry) and hard materials (mechanical engineering), spanning various colleges and departments.

For this symposium, a number of enthusiastic researchers from overseas were invited as a compilation of all activities up to date. More than 110 researchers and students exchanged information and presented achievements on their latest research results. A panel discussion, titled, "Initiatives for Highly Skilled Natural Science Professionals," was hosted by Dr. Shuichi Sakamoto (director of the MEXT University-Industry Collaboration and Regional R&D Division), Mr. Kumpei Kobayashi (president, Toshiba Materials), and Masanori Murakami (deputy president, R-GIRO). They engaged in a heated discussion from their own perspectives on how the formation of research cores and the development of highly skilled human resources could be made compatible.



Holding of the "Location-based Game x Machimirai: Tempozan GO! Forum"

On March 25, the "Location-based Game x Machimirai: Tempozan GO! Forum" took place at the Tempozan Passenger Terminal. This forum was planned and hosted by Minato Ward Office of the City of Osaka and the Osaka City Community Association, jointly with the Ritsumeikan Center for Game Studies (Kinugasa Research Organization) and Niantic, Inc., so as to enable the Chikko and Tempozan areas to become model areas for creating an environment where gaming can coexist with the promotion of attractive & lively town spaces via the improvement of gaming manner.

At the forum, Koichi Hosoi, professor of the College of Image Arts and Sciences (director of the Art Research Center) gave a keynote speech, titled, "Between Trips and Daily Lives: Pokemon GO and Media-Induced Movements." In the latter half, there was a panel discussion on the theme of "The future potential of location-based games and how they can impact communities." Panelists presented opinions on

community invigoration by utilizing location-based games and on the issues being faced by various communities as related to such games.

At the end of the forum, Hisanobu Tabata, mayor of Minato Ward, read the *Tempozan Declaration* and confirmed the aims of creating an environment where gaming can coexist with the promotion of attractive & lively town spaces via the improvement of gaming manner, with Chikko and Tempozan being the target model areas, all through the joint efforts of industry-academia-government partnerships.

Center of Innovation (COI) Program, "Active for All center," of the Japan Science and Technology Agency, Exhibits Research Results at the National Museum of Emerging Science and Innovation (Miraikan)

Research results from COI sites, so as to bring a "Active for All center," which is a Center of Innovation (COI) program of the Japan Science and Technology Agency, were exhibited at the Laboratory for New Media, in a permanent exhibition area, of the National Museum of Emerging Science and Innovation (Miraikan), for its 18th Exhibition, "Activate Yourself – Project for lazy athletes," from June 22.

The main representative of this exhibition is Professor Tadao Isaka of the College of Sport and Health Science. The concept is a future society where technologies to promote routine exercise are built in, so as to make "Health innovation by daily exercise" a reality. The manner in which smartwear can measure physical information was demonstrated, with audio speakers that can transmit sound selectively throughout various areas being on display, along with *oekakinden*, which can draw a picture based on information from one's muscles.

On the first day, a preview for members of the media and a study session took place. Professor Takanobu Nishiura of the College of Information Science and Engineering gave an account of the details involving the exhibits and the research on related studies.

The exhibition will continue until November 22.

National Museum of Emerging Science and Innovation (Miraikan)
https://www.miraikan.jst.go.jp/en/

Holding of the R-GIRO Symposium for Reporting Achievements: "Toward the Creation of Research Centers with Uniqueness for Global Society"

On February 24, an achievement-reporting symposium by R-GIRO* took place, with participation by about 150 people from both inside and outside Ritsumeikan University. This symposium was held mainly for reporting on research results from the four core research areas (the environment, sports & health, peace & governance, and Japan & regional research) of the Second-phase R-GIRO Research Program, titled "Establishment of Social Models to Co-exist with Nature" which was worked on for more than three years from the middle of AY2013.

At the symposium, Eiki Kominami, an executive advisor to the president at Juntendo University, gave a keynote speech, titled, "Maintaining Health by Autophagy – Proteins Cannot Survive without Being Destroyed" in the first part. R-GIRO Research Core leaders reported on overviews of projects, progress based on roadmaps, and other activities such as research results. In the second part, each core had subcommittees and held presentations on more detailed research results with a lecture by an invited presenter, in addition to panel discussions mainly by young researchers.

*R-GIRO: Ritsumeikan Global Innovation Research Organization

Awards Ceremony for the "11th Ritsumeikan Shirakawa Shizuka Awards for East Asian Characters and Culture"

On Saturday, April 22, an awards ceremony for the 11th Ritsumeikan Shirakawa Shizuka Awards for East Asian Characters and Culture was held.

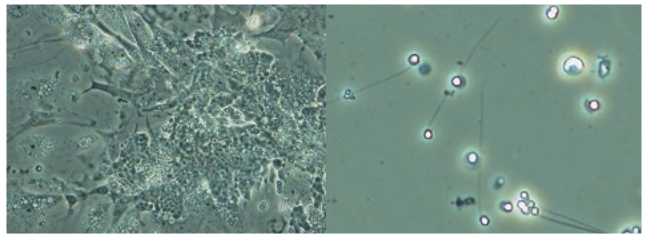
These awards, which are granted by the Shirakawa Shizuka Institute of East Asian Characters and Culture, aim to honor the achievements of the late Shizuka Shirakawa, professor emeritus of Ritsumeikan University, and to recognize individuals or organizations with a distinguished record in order to encourage and support talented human resources in the field of East Asian culture and ideogram usage (Chinese characters, etc.). For the 11th awards ceremony, an Excellence Award was given to Hiroyuki Sasahara, professor, Faculty of Social Sciences, Waseda University, and an Encouragement Award to Kentaro Narita, project research fellow, Uehiro Project for the Asian Research Library, University of Tokyo Library System. Takao Sugihashi, director of the Shirakawa Shizuka Institute of East Asian Characters and Culture, presented a testimonial and handed out supplementary prizes. Upon receiving the award, Sasahara expressed his pleasure by saying, "I will continue to devote myself to an endless study of Chinese characters (ideograms), contribute to the development of East Asian culture and ideogram usage, and solve the truth of Chinese ideograms to the best of my ability." Narita referred to his aspirations in relation to future studies by saying, "I will continue to learn from Dr. Shirakawa's attitude toward study so as to thoroughly read original texts and continue with studies that are worthy of his great name."

Following the ceremony, institute activities such as research results, educational activities, and community contributions were reported on and introduced.

Protecting the Endangered *Honmoroko* (*Gnathopogon caerulescens*) from Extinction: Even after Extinction, Spermatozoon Formation Possible *in vitro*

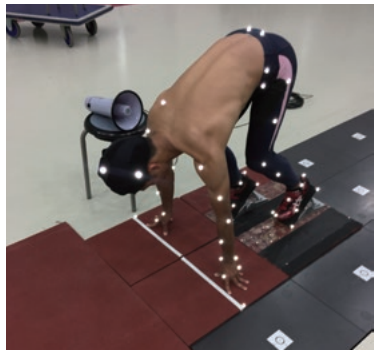
Working in conjunction with the National Institute of Genetics, the Shiga University of Medical Science, and Lake Biwa Museum, a group led by Professor Tatsuyuki Takada, and Assistant Professor Shogo Higaki of the Laboratory of Cell Engineering, College of Pharmaceutical Sciences, Ritsumeikan University has cultivated (*in vitro*) the spermatogonia (cells from which spermatozoon cells arise) of the honmoroko (*Gnathopogon caerulescens*), which is a species endemic to Lake Biwa designated as a critically endangered species, and has successfully developed a preparation method for fertile spermatozoa, making spermatozoon differentiation possible, without the need for parent fish. This achievement was reported on *Scientific Reports* (online version).

It is general practice to cryopreserve gametes (spermatozoa and ova) so as to preserve species of mammals, etc. However, as only a small amount of spermatozoa belonging to small endemic fishes has been available during brief breeding seasons, effective preservation methods for gametes have not been established. This study developed a method to cryopreserve spermatogonia present in the testis of fry, differentiated them *in vitro* in non-breeding seasons or as necessary to form spermatozoa, and confirmed that spermatogonia produced in incubators in a laboratory, as opposed to fish testis, were fertile, with individuals generated normally. It was also discovered that the ova of zebrafish can be used to investigate the fertility of spermatogonia of *Gnathopogon caerulescens* differentiated *in vitro*.



In vitro cultivation of spermatogonia   Spermatozoa formed *in vitro*

Timing of Gunshots Influencing Sprinters' Multiple Joint Reaction Times



Assistant Professor Mitsuo Otsuka of the College of Sport and Health Science discovered that during sprint running events, the longer the time between the "Set" command and the actual starting gunshot, the shorter the reaction time following such will become. Results were reported in *Frontiers in Psychology* (online version).

The subjects of the experiment consisted of 20 male sprinters, including seven runners that had taken part in international events (IAAF World Championships, Universiade, etc.).

At sprint running events, sprinters start their run by reacting to the gunshot following the "Set" command. However, under current regulations, the starter will subjectively determine gun-signal timing. For this reason, and depending on the race, reaction times can become longer for sprinters. It has been suggested under current regulations that a certain level of fairness may not be observed.

Currently, Japanese sprinters are expected to run 100 meters under 10 seconds. For sprinters to obtain good results, it is considered better for the starter to make the gun-signal timing longer, once it doesn't result in flying starts.

Professor Uemura Receives Honorary Doctorate from the University of Ss. Cyril and Methodius (Slovakia)

Masayuki Uemura, professor of the Kinugasa Research Organization (executive director of the Ritsumeikan Center for Game Studies) was awarded with an honorary doctorate from the University of Ss. Cyril and Methodius (Slovakia). This was a result of his invention of a new media form, the Family Computer, while working for Nintendo and his excellent contribution to the general development of game studies, as executive director of the Ritsumeikan Center for Game Studies since 2011.

With a 130-year history, the University of Ss. Cyril and Methodius is one of the most prominent universities in Slovakia, with departments and graduate schools, covering humanities, social science, physical science, and life science. It is especially well-known for mass media and marketing communication. The university has conducted exchanges with Ritsumeikan on game studies for almost a year now.

During an academic conference, Megatrends and Media 2017, at the University of Ss. Cyril and Methodius on April 25, Uemura gave a lecture, titled "The Japanese and Video Games." Afterward, a ceremony to present the honorary doctorate took place. Following this ceremony, local media were engaged in coverage, revealing a high level of interest in the event.

Eminent Professor Nagase Selected as Chair of Taiwan's International Review Committee

Osamu Nagase, eminent professor, Kinugasa Research Organization, has been elected to serve as chair of Taiwan's International Review Committee on the implementation of the UN Convention on the Rights of Persons with Disabilities (CRPD).

Though Taiwan is not a UN member and cannot officially ratify the CRPD, it passed an act to implement the CRPD, namely the Act to Implement the Convention on the Rights of Persons with Disabilities, in August 2014 and implemented it in December 2014. Based on the act, an international review of the convention is now in progress. In February 2017, after being commissioned by Vice-President Chen Chien-Jen, the International Review Committee, consisting of five international experts that were nominated by Taiwanese human rights experts and civil society, was established. In March, after mutual election by five committee members individually commissioned from the U.S., Canada, Sweden, Denmark, and Japan, Professor Nagase was elected to serve as chair. The committee will conduct its first review and make recommendations on the implementation of the CRPD in Taiwan for a five-day period starting on October 30, 2017. This is the first time for a Japanese national to serve as chair of an independent examination pertaining to the human rights treaties in Taiwan.

Professor Kita Wins E.C. Taylor Senior Award

Professor Yasuyuki Kita of the Research Organization of Science and Technology (professor emeritus, Osaka University) won the E.C. Taylor Senior Award, making him the third Japanese person to be honored with the award and the first Japanese recipient in 14 years.

The International Society of Heterocyclic Chemistry (ISHC) Senior Award is presented to outstanding heterocyclic chemists. Professor Kita achieved the first total synthesis of complex heterocyclic bioactive natural products, such as Discorhabdins C and A, Fredericamycin A, and r-Rubromycin.

The Negishi and Suzuki cross-coupling reactions forming carbon-carbon bonds became well-known following the receipt of the Nobel Prize. In order to produce these reactions, it was necessary to coat chemical compounds with metal or halogen or to use a rare metal catalyst. On the contrary, iodine reagents are used for Professor Kita's method, which makes such metals unnecessary and makes the cross-coupling reactions more useful. Therefore, his method is considered to be a revolutionary type of cross-coupling reaction, and is capturing global attention, as it allows not only conventional carbon-carbon cross couplings but also cross couplings of heterocyclic compounds containing nitrogen, oxygen, and sulfur, which have been difficult to produce with conventional technology . As his reaction does not require the use of rare or heavy metals, it has been regarded as a safe and sustainable form of "green" chemistry.

COLUMN #1 The World of Shirakawa's Letter Science

Core of Shirakawa Letter Science: "興" (Kyo)

Takao Sugihashi

Along with 𠙵 (Sai), which was covered in the first installment, Shirakawa Letter Science places importance on 興 (Kyo). With 𠙵 (Sai) as the starting point of Shirakawa's studies, looking into 興 (Kyo) was positioned as the core of Dr. Shirakawa's study of *Shi Jing* (*Classic of Poetry*) over a half-century ago. For his book, *Kyo no Kenkyu* (*Study of Kyo*), Dr. Shirakawa received a doctorate (literature) from Kyoto University. *Joyo Jikai* defines the sound of 興 as "Ko" or "Kyo," and summarizes it as a ritual where alcohol is poured into a 同, which is a glass held by both hands at the top and bottom, so as to invoke an earthy spirit. From here, the Chinese character developed meanings such as "raise," "start," "emerge," and "taste."

The outline of what *Kyo no Kenkyu* describes is as follows. In the traditional study of *Shi Jing*, 興 (Kyo) has been considered part of the rhetoric, and Dr. Shirakawa recognized a character of animism and preliminary celebration in a "興-like concept" and sensed the breath of rich ancient folklore and nature. It was thus analyzed that 興 (Kyo) is key to delving into the essence of ancient ballads, while elements in close proximity were identified in two collections of ballads in Japan and China, *Shi Jing* and *Manyoshu*, beyond time and space.

The comparative literary study of the two books thus started from this point, and the study of *Manyoshu*, the other pillar of Shirakawa's study on *Shi Jing*, resulted in *Shoki Manyo Ron* (1979) and *Koki Manyo Ron* (1995). Also, it is surprising that the study of *Manyoshu* was actually "one of Shirakawa's aspirations at all times" and that he was "determined to study ancient Chinese literature first" in order to "prepare for *Manyoshu* study" (from the epilogue for *Shoki Manyo Ron*).

Shizuka Shirakawa, *Kyo no Kenkyu*

As reading material for graduate school, *Kyo no Kenkyu* was published together with *Tsuron Hen* (*Outline*) and *Kaishaku Hen* (*Interpretation*) in 1960. These were published in A5 size format, at 360, 670, and 450 pages, respectively. Dr. Shirakawa himself wrote on stencil paper using a metal stylus for mimeographing (See *Kaishi Kyujunen* [*Looking Back on 90 Years*]). It is from here that we can see his extraordinary ability and great effort.

Kyo no Kenkyu Table of Contents (partial)

Mimeography is probably an unfamiliar word for many people these days. The photograph below shows a set of mimeography tools used at Ritsumeikan University.

Top photograph: In the possession of Shirakawa Bunko, Ritsumeikan University Library
Bottom photograph: Source: Ritsumeikan Archive Center

Takao Sugihashi Director of the Shirakawa Shizuka Institute of East Asian Characters and Culture/ Professor, Kinugasa Research Organization and Professor Emeritus

COLUMN #2 Viewing the World via Infrared Rays

Seeing Invisible Things

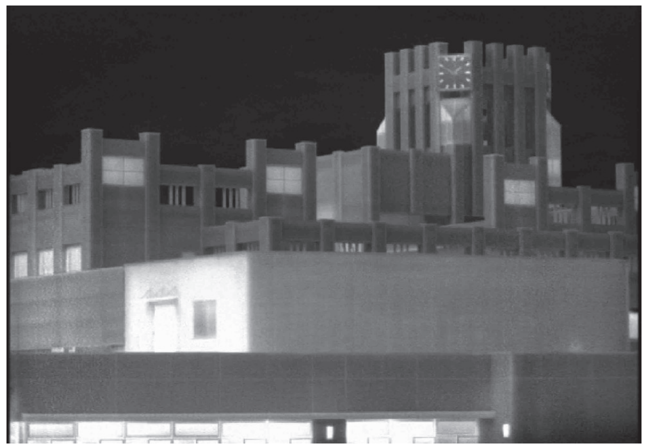
Masafumi Kimata

Human beings acquire information from the outside world using the five senses of seeing, hearing, smelling, tasting, and touching. However, the amount of visual information that the human body takes in is overwhelming, as it is said to account for about 90% of the total. This is due to the fact that what people can acquire using vision is 2D information, including color information. However, the human eye can only see a very narrow band of wavelengths known as "visible light," out of a band of electromagnetic waves, and only the wavelengths that meet certain conditions are transmitted to the brain as visual information. Human beings can only perceive visible light that satisfies specific conditions. Throughout its long history, the human race has attempted to make different invisible electromagnetic waves visible, in order to extend their vision.

Such an attempt to see the invisible not only satisfies human interest, but also has practical meaning. We can obtain very useful information due to related technology. For example, we can see high-speed phenomena, we are able to look through things, we can see the distant, and we can see the micro. The human eye cannot recognize each frame when looking at changes at a speed of 30 frames per second, but semiconductor technology enables high-speed image pick-up at more than one million frames per second. Meanwhile, fluoroscopy by X-ray is widely utilized for health checkups and airport security, large telescopes for astronomical observation allow us to see to the end of the universe, and transmission electron microscopes reveal the configuration of atoms in a substance.

I have been involved in the R&D of infrared image sensors that capture infrared rays invisible to the human eye, as images, for a period of 37 years. The illustration below shows the Across Wing at the Biwako-Kusatsu Campus of Ritsumeikan University, as taken with an infrared camera. This infrared image is obtained by detecting light radiating from the buildings, not the light reflected by them. As the light received by the camera is that radiated by substances, using an infrared image sensor enables us to obtain an image much like an illustration even in pitch-black darkness (night vision). Furthermore, the amount of radiated light depends on the temperature of the substances, and the infrared image sensor is also used for measuring 2D temperature distribution without any contact.

The usefulness of infrared image sensors is being recognized more and more, which pleases me as a researcher. I have been able to maintain my motivation for 37 years, as I always consider that seeing invisible things is interesting, and unexpectedly simple things make people enthusiastic.



Biwako-Kusatsu Campus, as seen as an infrared photograph

Masafumi Kimata Tokunin professor, College of Science and Engineering
Acquired doctorate (engineering) at Osaka University in 1992. Worked for Mitsubishi Electric Corporation since 1976. After being engaged in R&D of infrared image sensors, appointed professor, College of Science and Engineering, Ritsumeikan University, in 2004, and assumed current position in 2017. Awarded the Commissioner of the Patent Office Award, Kinki Region Invention Recognition in 1992, Prime Minister's Invention Award at the National Invention Awards in 1993, etc. Serves as an invited staff member at the Japan Aerospace Exploration Agency since 2009.

COLUMN #3 College of Comprehensive Psychology regular column

Trajectory Equifinality Approach: Qualitative Research Methodology for Society and the Future

Yuko Yasuda

Have you ever heard of the research methodology of Trajectory Equifinality Approach (TEA)? This is the qualitative research methodology that originated in the U.S. and that was further developed in Japan. TEA is based on Trajectory Equifinality Modeling (TEM), which is the method illustrating the multiplicity and diversity of human development and life course, in conjunction with the theory for choosing subjects (Historically Structured Inviting: HSI) and the theory to understand and describe transformations of selves (Three Layers Model of Genesis: TLMG).

TEM, as the foundation of TEA, was developed on the basis of Jaan Valsiner's original idea that incorporated the concept of Equifinality into psychological researches pertaining to developmental and cultural events. Under the concept of Equifinality, human beings are grasped as open systems and considered as existences that equally (equi) reach (final) a certain steady state, while following diverse trajectories as they are affected historically, culturally, and socially over time. The actualized Equifinality is conceptualized as Equifinality Point (EFP). In research, actions and selections are focused as Equifinality Points, and with people that have experienced such Equifinality Points as subjects of research (HSI), we illustrate the trajectories reaching these Equifinality Points. In grasping the diversity and multiplicity of trajectories, Bifurcation Point (BFP) is also an important concept. Bifurcation Points are conceptualized as points where trajectories are divided. From the viewpoint of what transformations are taking place at Bifurcation Points, TLMG is most useful. (See Figure-1.)

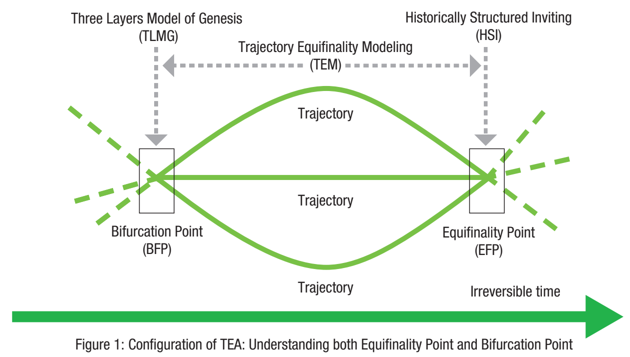


Figure 1: Configuration of TEA: Understanding both Equifinality Point and Bifurcation Point

TEA is widely applied to researches and practices so as to comprehend processes and transformations. In addition to narrative data on life stories, behavioral observation data such as child play development are also subject to analysis. TEA is utilized in a wide range of academic fields: clinical, developmental, cultural psychology, early childhood care and education, nursing science, linguistics, sociology, management and so on. It is examined from multiple aspects regarding how it can approach human life, for example, connectivity with other qualitative research methods such as the KJ Method, narrative approach, and Dialogical Self Theory (DST). Over the past several years, we have conducted joint research with the automobile manufacturer, Mazda Motor Corporation (representative: Tatsuya Sato, professor, College of Comprehensive Psychology). This joint research shows that, in product development, having a viewpoint involving human life is essential. TEA has been developed as the research methodology that can contribute to industry-academia cooperation. We will continue to examine other possible applications for social implementation.

The view of human beings as underlying the TEA view of things is very humane, and it has greatly supported me in my research activities. TEA approaches human life from a non-linear view, in addition to potential and possibilities. Please look out for the future of TEA.

Yuko Yasuda Associate professor, College of Comprehensive Psychology
Acquired doctorate (education) at the Graduate School of Education, Kyoto University in 2010. Assumed current position in 2015. Recognized by the examiners (document review) of the Screening Committee for Research Fellowships for Young Scientists, Japan Society for the Promotion of Science, in 2012. Co-authored *Word Map TEA: Theory* and *Word Map TEA: Practice* (shin-yo-sha)

Research Office

The Research Office has a goal of contributing to society through research exchanges, technological transfers, support of ventures, etc., utilizing the intellectual assets of the university. To centralize information on researchers in the university and their diverse external needs and to promote industry-government-academia activities more smoothly, depending on the challenges involved, we serve as an integrated point of contact for all the various matters associated with research.

Research Office at Kinugasa Campus

Humanities and Social Sciences

College of Law, College of Social Sciences, College of International Relations, College of Letters, College of Image Arts and Sciences, Graduate School of Science for Human Services, Graduate School of Language Education and Information Science, Graduate School of Core Ethics and Frontier Sciences, Graduate School of Law, Graduate School of Public Policy, Graduate School of Professional Teacher Education

56-1 Toji-in Kitamachi, Kita-ku, Kyoto 603-8577, Japan
TEL: +81-75-465-8224
FAX: +81-75-465-8245
Mail: liaisonk@st.ritsumei.ac.jp

Research Office at Biwako-Kusatsu Campus

Social Sciences | Natural Sciences

College of Economics, College of Sport and Health Science, College of Science and Engineering, College of Information Science and Engineering, College of Life Sciences, College of Pharmaceutical Sciences, College of Gastronomy Management (Scheduled to open in April 2018)

1-1-1 Noji-higashi, Kusatsu, Shiga 525-8577, Japan
TEL: +81-77-561-2802
FAX: +81-77-561-2811
Mail: liaisonb@st.ritsumei.ac.jp

Research Office at Osaka Ibaraki Campus

Social Sciences

College of Policy Science, College of Business Administration, College of Comprehensive Psychology, Graduate School of Technology Management, Graduate School of Management

2-150 Iwakura-cho, Ibaraki, Osaka 567-8570, Japan
TEL: +81-72-665-2570
FAX: +81-72-665-2579
Mail: oicro@st.ritsumei.ac.jp

Contact Us

Latest information on research activities

Ritsumeikan University
Research and Industry-Academia-Government Collaboration website
http://en.ritsumei.ac.jp/research/

For inquiries in relation to RADIANT, the Ritsumeikan University research report, contact:

Office of Research Planning & Development,
Division of Research, Ritsumeikan University
TEL: +81-75-813-8199 FAX: +81-75-813-8202
E-Mail: res-plan@st.ritsumei.ac.jp