Chapter 1 The Advent of a Super Smart Society

The development of automobiles, public transportation systems and the improvement and popularization of home electronics have brought significant benefits. For example, we can travel and do housework in less time than before, and our physical labor has become lighter. The advent of radio, television and computers and the explosive growth of the Internet since the 1990s have made it possible for people to instantly obtain a variety of information from around the world. As a result of significant increases in the speed and capacity of information and telecommunications networks in recent years, combined with the diffusion of smartphones and tablet computers, people can access media content such as videos and music and can do Web searches anytime and anywhere by using a single mobile terminal. In the past, multiple devices were necessary for doing these things. Increases in the processing capacity of computers and advancements in big data analysis technology and artificial intelligence help to continuously create new services that integrate things and information to make our lives more affluent and comfortable.

Chapter 1 focuses on the changes to our lives that will be brought by the integration of cyberspace and real space. Such integration is being accelerated by advances in networking, big data analysis technology and artificial intelligence. The future of Japan's super smart society is envisioned in specific terms in light of the social problems for which Japan is under pressure to find solutions. By identifying the characteristics of a super smart society that are associated with such solutions, Japan's super smart society is outlined as a society where cyberspace and real space are highly integrated. Additionally, significant changes in economic activities and social systems are described as the likely outcomes of the development of a super smart society, and economic ripple effects of the development of such a society are considered.

Section 1 Japanese Society in the Future

In Section 1, Japanese society 20 years from now is envisioned from the viewpoint of citizens' daily lives. For this purpose, the daily life of a fictitious family is described below.

Japan is confronting problems such as an increase in social welfare spending due to demographic aging, labor shortages caused by decreases in the working-age population, and declines in the vitality of regional communities. Twenty years from now, in 2035, the oldest children of the post-war baby boomers will turn 65, the age when they are called the elderly. The world population is expected to reach 8.8 billion in 2035, chiefly because the population of developing countries has been significantly increasing[1]. Against the backdrop of the expected world population explosion plus improvements in people's living standards and the impacts of climate change, it has been pointed out that supplies of energy, resources, food and many other things are likely to be insufficient in the future. So how are science, technology and innovation able to address these domestic and global issues? Towards answering this question, Japanese society 20 years from now is envisioned. The year 2035 is chosen because the results of much exploratory research currently under way are likely to have been put to practical use by that year.

1 *World Population Prospects: The 2015 Revision*. The United Nations.

Each vision of a future Japanese society below represents a feasible picture, or a fragment of a super smart society. Japan has been facing the problems mentioned above, and a vision of the future that the country pursues towards solving these problems will be realized, for the most part. Still, such a vision depicts just a part of our future society, and it should be remembered that we will be creating a major part of the future society that we desire. For this purpose, we need to exercise our curiosity, seek pleasure in life and identify things that we want to obtain, try or change.

＜The Masuda Family＞

Five family members across three generations...Father: Masashi (50); Mother: Miki (48); Daughter: Ai (22); Son: Theo (11); Mother's father: Shun (78) The Masuda family is living in Tokyo in 2035. Masashi works at the Disaster Control Center, and Miki is an architect at a construction company. Their daughter is a fourth-year university student who is trying to find employment, and their son is a sixth grader. The Masuda family owns the Gennai robot, which serves as a commander for other robots working for the family.

Masashi's mother, Chie, is 90 years old. In the outlying city where Masashi was born and raised, Chie is living in a nursing home for the elderly near the house of Masashi's elder brother.

＜Names of the family members＞

In 1956, The Dartmouth Summer Research Project on Artificial Intelligence was held at Dartmouth College in New Hampshire, U.S.A. Reportedly, the term "artificial intelligence" was introduced for the first time at this conference. The family name and the first names of the family members were coined on the basis of the title of the conference and the names of the researchers who attended the conference. The names on the left were used for coining the names shown at right:

Dartmouth ⇒ Masuda

John McCarthy[1] ⇒ Masashi (Father)

Marvin Minsky[2] ⇒ Miki (Mother)

Artificial intelligence (AI) ⇒ Ai (Daughter)(Ai was born at the Dartmouth Summer Research Project on Artificial Intelligence, and Ai was born to the Masudas.)

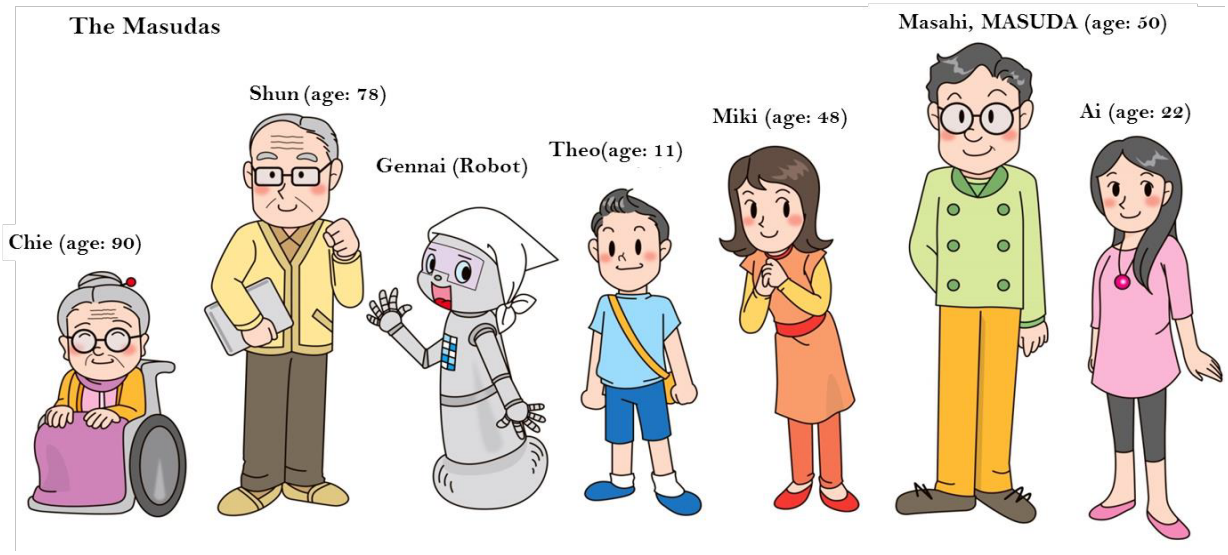
Logic theorist ⇒ Theo (Son)(The Logic Theorist, the world's first artificial intelligence program, was presented at the Dartmouth Summer Research Project on Artificial Intelligence.)

Claude Shannon[3] ⇒ Shun (Grandfather)

Nathaniel Rochester[4] ⇒ Chie (Grandmother)

Notes:

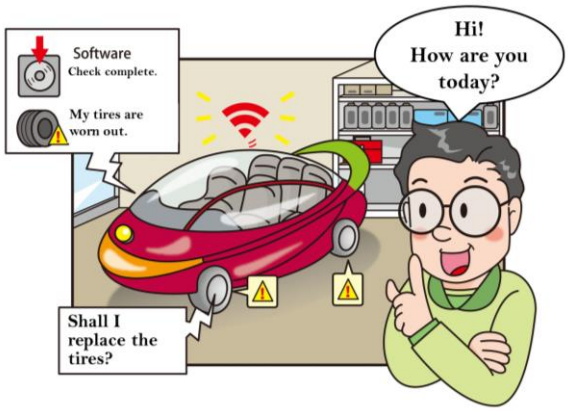
1 A computer scientist and cognitive scientist. One of the key attendees at the Dartmouth Summer Research Project on Artificial Intelligence. He coined the term "artificial intelligence."
2 A computer scientist and cognitive scientist. Co-founder of the Massachusetts Institute of Technology's Artificial Intelligence Laboratory
3 An electrical engineer and mathematician. He is known as the father of information theory.
4 A key member of the team that developed the IBM 701, the first general-purpose, mass-produced computer.



1 Purchasing Customized Goods and Friendly Services

＜In the garage at home＞

On a holiday morning, Masashi is in his garage talking to his beloved electric car. "How're you doing?" he asks. "My self-driving software was updated last night," the car answers. "Your tires are low on air, so please put some air in them before you take me out for a drive." And you've received a notification to change your tires because they're worn. Tires of the specifications and quality optimal for the surface condition of the roads you most frequently drive are available. Is it OK with you if your tires are changed?" Masashi answers, "OK." New tires and a robot specializing in changing tires will visit his home today or tomorrow.



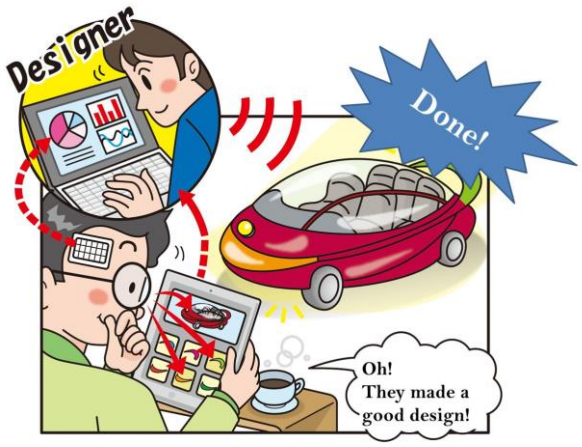
Ever since he was young, Masashi has enjoyed customizing his car and using the upgraded car for many years. Many people, including his father-in-law, who lives under the same roof, say they enjoy driving the compact cars that a community car-sharing program offers, but Masashi wants to own a car. He bought an electric car recently, his first car in more than

10 years. The car he owned before was basically a self-driving car, but he had to respond to any emergencies manually. His new car is fully autonomous. He decided to buy a new car because most drivers are using fully autonomous cars these days and the public has become increasingly anxious about the safety of cars driven by people.

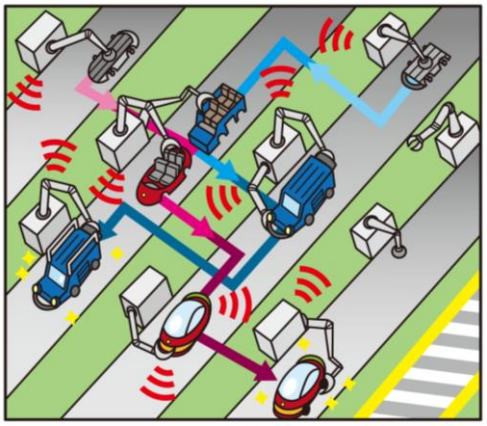
＜The process of purchasing the car that Masashi liked＞

Masashi was surprised to learn that the process of purchasing a car had totally changed. After visiting a free website to view various car models and parts, he received several design proposals from an automobile designer. On the basis of the car design that Masashi scrutinized on the website and by referring to

analyses of customer responses to, and evaluations of, design proposals, the designer sent Masashi some proposals that the designer thought Masashi would like. Masashi checked the full-size 3D images of the car design from all directions to give feedback to the designer, and decided to accept a modified design proposal that the designer created on the basis of that feedback.



The finalized car design was sent to a car-assembly plant, and a new car was delivered to Masashi just a few days after he placed the order. At that plant, many cars designed for other people are simultaneously manufactured. Various parts and components move along an assembly line, and multiple robots specializing in specific tasks assemble these parts and components into cars. About a decade ago, different assembly lines and manufacturing processes were used to produce various models of cars. But now a flexible production system makes it possible to simultaneously manufacture different cars on the same assembly line. Thanks to this system, the custom-designed car that Masashi bought was nearly the same price as a mass-market car, so his wife didn't complain so much about his spending on the car.



＜Saving energy and resources＞

Masashi got in his new car and told it where to take him. Soon a route that would get him to his destination in a time-efficient manner was suggested by the Traffic Management Center, and the route was displayed on the screen in front of him. The Traffic Management Center suggests routes to drivers on the basis of the locations of large numbers of moving cars, their destinations and the data the Center collects every day for traffic prediction. Depending on changes in these data, the Center may give modified suggestions to drivers en route.

For the route selection, Masashi gave priority to driving safety, electrical efficiency[1] and extension of the car's service life. Thus, routes are chosen for him on the basis of road surface conditions and road sections where traffic accidents have occurred. The data on Masashi's driving safety, electrical efficiency and distances traveled are sent to the car manufacturer. Service fees are reduced when the data show his car to have improved performance. Service fees are fees for the extended warranty for repairs and the automobile liability coverage in the event of a car accident, and these fees change according to driver's use of the car.

Car manufacturers suggest the need for repairs on the basis of their accurate understanding of the slightest sign of motor or brake failure. Components that had once been assembled from many parts are

1 Electrical efficiency is an electric vehicle's rate of electrical consumption. It is equivalent to fuel efficiency in a petrol-powered vehicle.

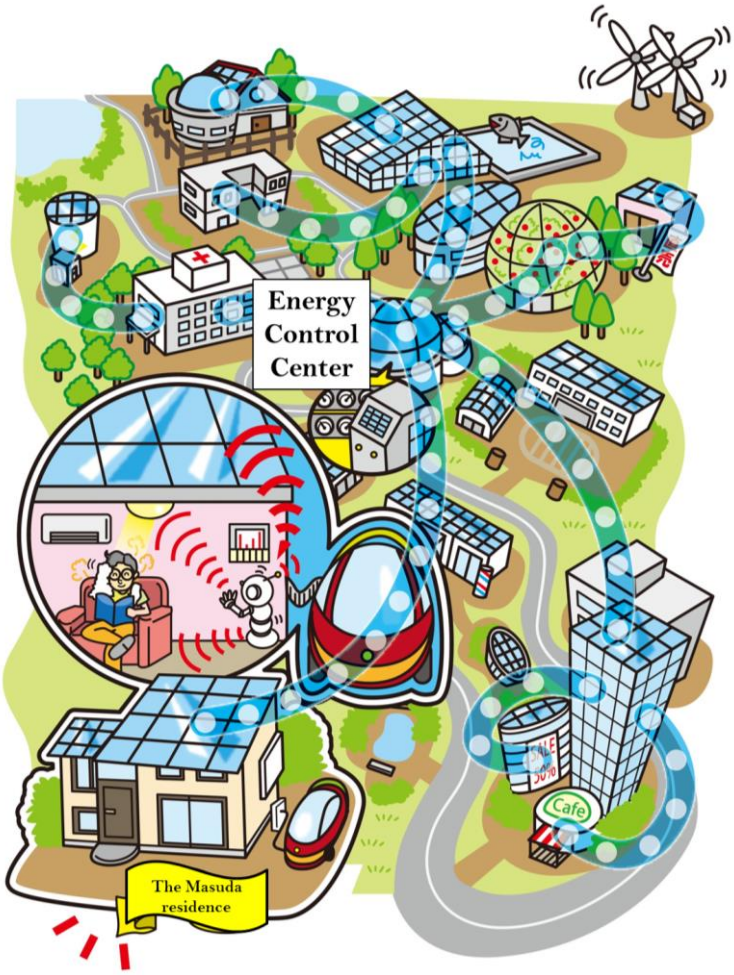
now cast with a 3D printer. Such casting allows for the quick and precise production of light, durable components. For the sake of repair efficiency, components are modularized[1] to minimize the number of components that need to be replaced. For car owners who want to remodel their cars, it is possible to change the appearance of the car without replacing the integrated components.

2 Town Planning and the Local Production of Energy for Local Consumption

＜Daily life and energy＞

Masashi's electric car contributes to the efficient use of energy. The Masuda family uses electricity that is generated directly from sunlight during the day to meet its electrical power needs at night. Surplus electricity is used for charging their electric car. In the event of a power outage due to a disaster, their photovoltaic device is used in the community as one of many dispersed power sources.

"Another day and another nice bath," Masashi says with a look of satisfaction, lying on the floor of the living room. He begins reading a book. A robot called Gennai is responsible for managing the supply and demand of energy at home. Gennai adjusts the temperature and quantity of water in the bathtub in an economical manner by taking into account the preference of each family member and the time of day when each individual member takes a bath. Gennai keeps data on the behavioral patterns, body temperatures and locations of family members, and controls the levels of light and room temperature for each space where family members spend time. Masashi no longer gets into tiffs with his wife about the room temperature and the electric bills. In this way, science and technology are helping to secure the happiness of the Masuda family.



＜Regional energy management＞

As in many other towns, the Masuda's town relies on solar photovoltaic power generation or biomass thermal energy to power office buildings and commercial facilities. The electricity generated at these buildings and facilities is accumulated in large-scale battery systems. The Energy Management Center in

1 Organizing components into stand-alone modules so that combinations of these modules can make up the internal design of a product.

the town monitors the supply and demand of energy for the entire town and coordinates the supply of energy among buildings.

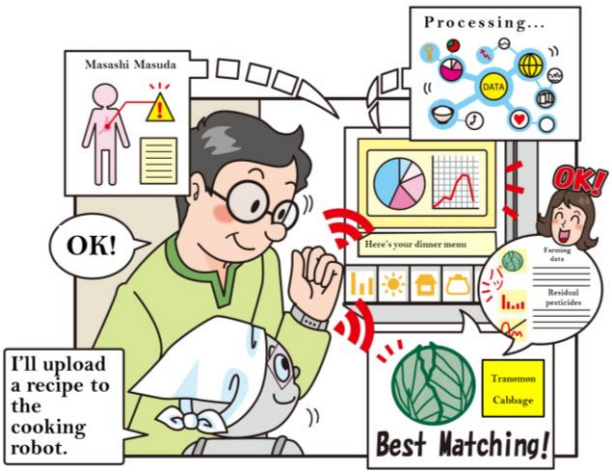
For instance, office buildings have a high demand for electricity during the daytime on weekdays, and these buildings get electricity from commercial facilities that have a low demand for electricity. On weekends and holidays, electricity demand at commercial facilities increases, and electricity from office buildings is used to balance the shortfall. In the event of a prolonged power outage, electricity is supplied to the Masuda family from large-scale battery systems in order to secure a minimum level of living.

Power companies used to supply electricity to each office building and commercial facility. Because of reductions in the installation costs for power-generation units, significant increases in power generation and storage capacity, and the development of a system of mutual support for energy, the local production of energy for local consumption is pursued to a maximum extent. When necessary, electricity is purchased from power companies.

3 Desirable Crops Grown to Order

＜Preparing dinner at the Masuda home＞

One Sunday midafternoon, Gennai tells Masashi, "It's about time you decided what to cook for dinner." After analyzing the physical conditions and tastes of the family members based on data from wearable devices and based on what they have eaten, what ingredients are on hand, the current market conditions and millions of recipes on the Internet, Gennai says, "You have a sensitive stomach now, so I recommend recipes using fish and vegetables. Cabbage grown to order at Toranomon Farms would be good for these recipes."

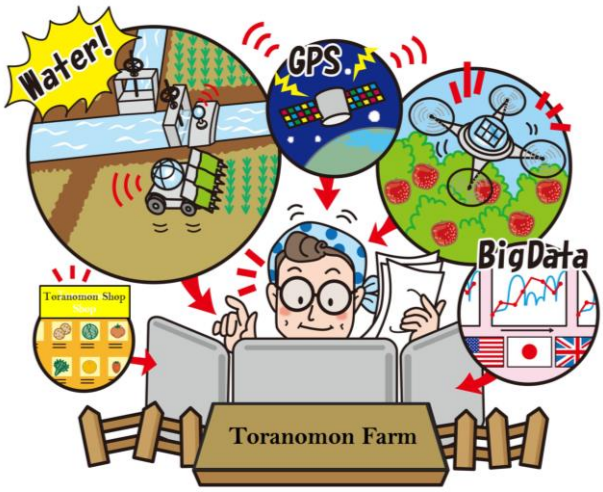


Gennai adds, "The cultivation records and the test results for residual pesticides show that cabbage from that farm satisfies our desired conditions." As a rule, Masashi's wife, Miki, takes responsibility for determining menus, ordering ingredients and doing the cooking, whereas many other wives let their robots do these things. But she is at work and not at home. Masashi says, "All right."

In a vegetable warehouse at Toranomon Farms, a robot swiftly puts cabbage into a package. Because the farm uses drones for short-distance delivery, Masashi will be receiving the cabbage and a thank-you note from the farm in the evening. Gennai has already installed a robot chef with the software needed for cooking today's dinner.

＜Business strategy of Toranomon Farms＞

At Toranomon Farms, agricultural machines automatically till the soil, eradicate weeds and do other jobs day and night. Irrigation facilities are automatically controlled for each of many rice fields in order to respond to their different growth statuses. Images showing fields and orchards are sent from drones. These images are used for determining whether the robots need to repair paddy field boundary ridges and remove



weeds. In this way, Toranomon Farms has achieved great labor-savings and large-scale production at vast fields that are dispersed in a wide area.

The manager of the farm leaves the big data analysis to artificial intelligence, which allows consumer needs worldwide to be understood, demand to be forecast, and crop yields, harvest times and crop quality to be predicted. Using the big data analysis results, the manager spends most of his time developing management strategies for optimum production of proper crop species in the right places at the right time. The manager also performs business transactions by utilizing a sales order management system. Through consistent management from production to sales, only the required quantities of crops are produced and shipped out at the right moment in an effort to reduce food loss. Crops produced at Toranomon Farms are exported to many countries.

＜Mother as a collaborator with the farm＞

Toranomon Farms has been producing crops in collaboration with consumers in order to precisely respond to their needs. Miki answered an ad placed by the farm last year about collaborating with the farm.

The agricultural database accessible to the public has chromosome maps of various crops. Various regions of the genes for these varieties are shown in association with specific crop qualities such as tastes and textures. Because data have been accumulated on "master techniques" that experienced farmers have developed for growing crops and ensuring their quality, it is possible to analyze and identify optimum combinations of cultivation conditions and crop varieties in order to obtain the desirable qualities of crops. By applying data on Miki's preferences to the analysis results regarding such combinations, Toranomon Farms offers several virtual samples of vegetables with specific flavors. Miki uses an apparatus to virtually taste these samples, and she tells the farm that the virtually sampled vegetables taste good.

Toranomon Farms begins growing vegetables that suit Miki's tastes. Agricultural machines take measurements of soil components while plowing the soil, and blend and apply fertilizer to achieve specified optimum cultivation conditions. Miki worries about how much fertilizer is applied, but a minimum amount is used because agricultural machines apply only the necessary quantity in a timely manner by referring to forecasts of disease and pests that are based on detailed weather information. Some people prefer cheaper crops that are grown in plant factories, where cultivation conditions are easily controlled. These crops are also grown to suit the tastes of each individual consumer. But Miki prefers crops that have grown in soil with plenty of sun.

Agricultural production has changed by incorporating the idea that various products should be produced in multiple ways to satisfy the diverse needs of consumers. As part of this idea, a thank-you note is included in the package of cabbage ordered by Gennai.

＜Contributing to solutions to global issues＞

The agricultural database used by Toranomon Farms is shared globally. Thanks to crop breeding that

utilizes chromosome maps and DNA markers[1], it takes much less time than before to develop improved varieties. Data have been accumulated regarding the varieties that are tolerant of high-temperature injury, salt damage, diseases and pests, as well as varieties that are several times more prolific than conventional ones. In many places around the world, these data have been used to facilitate the introduction of new varieties that are resistant to the climatic effects of global warming.

4 Healthcare Management on a Daily Basis

＜Beds that play critical roles＞

When Miki's father, Shun, woke up that morning, the first thing he saw was the ceiling, onto which his bed was projecting graphs and figures. These graphs and figures indicated Shun's blood pressure, heart rate, and other vitals that had been monitored while he was asleep. He was relieved to see that there were no abnormal readings and that an analysis of his breath indicated no risk of diabetes. He was evaluated as having slept well, based on data from a sheet adhered to his forehead. Shun had slept well because his bed had adjusted his body position by rolling him over. Masashi ordered a tailor-made car. Shun has a bed that was designed to satisfy his preferences, including his desire for precise healthcare management, which is a priority for him. Since Shun began using the bed, he has installed various software applications in order to try out different measurement functions and to make the bed more comfortable.

Shun attended a high-school reunion the other day. One of his old friends there told him of having been taken by ambulance to a hospital in the middle of the night about half a year before. Shun's friend fell ill shortly after purchasing a bed with sensors that the friend thought were necessary, as he was living alone and had reached an advanced age. While asleep, he suffered a cerebral infarction and remained unconscious. The sensors in his bed detected his abnormal condition, and data were immediately sent to the Emergency Department of the Traffic Management Center (cf. "1 Purchasing Customized Goods and Friendly Services"). The artificial intelligence at the Traffic Management Center recognized that taking him to a hospital had the greatest urgency. That artificial intelligence instructed the ambulance nearest to his house to take him to the hospital that the artificial intelligence had chosen after analyzing various statuses of local emergency hospitals. The artificial intelligence also instructed the ambulance on the optimal route to his house.

Shun's friend was able to be taken immediately to an emergency hospital because his home security

1 This is a breeding technique that utilizes genetic markers associated with important traits to easily screen plant lineages with desirable qualities. The Japan Prize Foundation. Japan Prize News No. 55. January, 2016.

system was set to allow emergency service workers to temporarily unlock his door in case an emergency vehicle came to his home for rescue. Because of the success of a clot-dissolving drug therapy, Shun's friend made a complete recovery and suffered no after-effects. His doctor didn't hesitate to start him on that therapy, because the patient data was shared with the hospital to which he was taken, so the doctor knew the exact time of onset for his cerebral infarction[1].

He was able leave the hospital in a relatively short period of time, and he doesn't need to see the doctor regularly, because his wearable devices send data on his vital signs to the hospital for health monitoring.

＜Science and technology that help maintain the health of family members＞

At Masuda's home, Gennai keeps the room temperatures at the proper levels for each family member. While filling the bathtub with hot water, Gennai adjusts the temperature of the changing area such that they won't feel cold before and after taking a bath. Thus, the risks of sudden blood pressure increases and myocardial infarction are reduced. A wide variety of information is sent from their home for accumulation at the Center for the Protection and Utilization of Personal Information. The information includes the results of human waste component analysis by the toilet, data on allergens contained in dust collected by a robot vacuum cleaner and in water in the washing machine, and measurements taken by beds and wearable devices. The Center for the Protection and Utilization of Personal Information is an institution that processes enormous volumes of personal data into anonymous information and provides such information to various services (cf. Section 2, Chapter 2).

For example, analysis of data from patients with certain diseases has helped us to understand the biological phenomena that occur immediately before the onset of these diseases, and has helped facilitate accurate diagnoses and preemptive therapies for these diseases. Regarding dementia, its pathogenic mechanism was unraveled and effective drugs were developed. Now it is possible to significantly delay the progression of dementia symptoms and even to prevent the onset of dementia.

Beds with sensors and wearable devices send data to a specified hospital when the data indicate the need for a doctor's examination for signs of disease. Recently, Shun received a comment from a doctor about his blood pressure, which had been relatively high, together with a plan from the doctor for altering Shun's diet and encouraging him to exercise. Because Gennai shared the plan and recommended delicious recipes by referring to the doctor's instructions, Shun's blood pressure has dropped to a normal range.

Various services available at home have made telediagnosis and telemedicine possible. These services are saving many people who were at risk of seeing their disease become chronic or otherwise aggravated.

Advancements in big data analysis technology and artificial intelligence have led to development of infrastructure for telediagnosis and telemedicine. Thus, people living in regions without specialist doctors can have access to safe, high-quality medical services.

Masashi also uses wearable devices to help overcome his aversion to exercise and to improve his diet. Even with the help of devices, it is not easy to keep making efforts to maintain one's health. But Masashi is serious about trying to stay fit, because he knows that his medical insurance premium will be lowered if the data sent to his insurance company show that he has a healthy lifestyle.

Shun recognizes the significant contributions that advances in science and technology have made to

1 "New Treatments for Cerebral Infarction," Cerebral and Cardiovascular Disease Information Service No. 63, National Cerebral and Cardiovascular Center (http://www.ncvc.go.jp/cvdinfo/pamphlet/brain/pamph63.html)

reductions in medical and nursing care expenses.

＜Exercising one's abilities on the home ground＞

Shun worked at a Japanese restaurant in his early years. Because he doesn't have to take the time to see a doctor or receive treatment thanks to advances in science and technology, and because he wants to keep working, he has been serving as a lecturer for programs attended by the public. In these programs, which focus on traditional Japanese food, he partners with an acquaintance to teach how to make soba, or buckwheat noodles, and rice porridge with seven kinds of spring herbs. Hands-on learning of rice-cake making at elementary schools and elsewhere is very popular. In the class, Shun starts out by teaching how to cook glutinous rice on a stovetop. He enjoys taking walks partly because he sometimes meets and exchanges greetings with children he's acquainted with.

Because his class schedule is registered with the Traffic Management Center, a compact two-seat electric car was autonomously guided to his home today, a day he has a class, to pick him up at the right time. His acquaintance was already in the car. It's nice to sit in Masashi's favorite car for a long drive with other family members. But Shun also likes small cars that consume little energy and are just perfect for visiting nearby places.

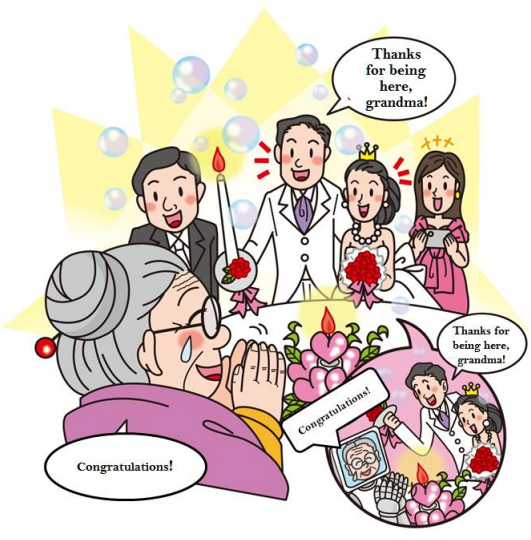
5 The Joys of Everyday Life at a Nursing Home

＜Enjoying life with family and robots＞

Masashi's mother, Chie, had lived free from serious illness disease until that age of 90. After being injured in a fall two years ago, she hasn't been able to get out of bed to go to the bathroom unassisted. Masashi's elder brother and his wife work outside the home, so it's difficult for them to be at home at about the same time each day to take care of Chie. Because the time available for them to look after her is limited and because she wanted to be able to receive physical therapy, Chie moved into a nearby nursing home for the elderly.

Now Chie is living apart from her family, but she enjoys chatting with her sons and grandchildren whenever she likes. In Chie's room at the nursing home, she can view real-time images of Masashi's living room. Chie hears the happy voice of Masashi's son Theo. She feels as if she is sitting with Masashi's family.

Chie also likes to enjoy various events at the nursing home. The nursing home has a robot entertainer that is good at entertaining residents every day by superbly emceeing karaoke singing competitions, performing magic shows, playing ball games and chatting with residents. Because the biological phenomena that immediately precede the onset of dementia and depression have been clarified, diagnostic and therapeutic techniques for these diseases have improved. Additionally, active involvement by robots, such as the robot entertainer, in the daily lives of the elderly must be greatly helping to prevent disease.



＜Attending the wedding of one's grandchild＞

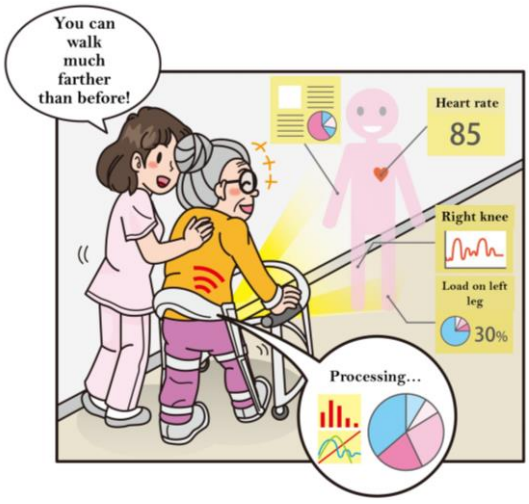
The other day, Chie attended the wedding of her grandson, a son of Masashi's elder brother. She

joined in a toast to her grandson's marriage, together with relatives she hadn't seen in years. When the bride and groom came to her table to light a candle on it, she congratulated them. She was happy to have lived long enough to be there. This was possible thanks to a robot. In fact, she was unable to go out to attend the wedding, so she used a robot that was programmed to behave according to Chie's wishes. Chie's face was projected on the face of the robot. In Chie's room at the nursing home, 3D images of the wedding hall were projected on the wall. She was able to look around the hall and feel as if she were sitting in the hall. Her grandson was glad and said afterwards, "I was happy because I felt grandma was actually with me there."

＜Robots that support nursing home residents＞

Every day, Chie trains herself to walk and sit up with the help of a robotic exoskeleton that supports her physical rehabilitation. The wearable exoskeleton assists Chie in moving by sensing her intentions. Chie can keep sitting straight up in bed for a while these days, and she has become fairly good at putting on the exoskeleton. That is partly because the recent wearable exoskeletons are much lighter than the old ones. She has tried to walk every day, even if only for a short distance. Now she can take longer walks than when she was a newcomer to the nursing home, so she is motivated to live a long life. She is committed to her physical rehabilitation, with the aim of returning home in the future.

The residents of the nursing home include those who became disabled due to illness. Rehabilitation support robots assist such residents in moving, while helping enhance their functional recovery. These robots quickly analyze vast amounts of data on the effectiveness of physical therapy that is correlated with specific clinical cases as well as on the physical conditions of each resident with a disability. Based on the analysis, the most effective rehabilitation method and intensity are suggested to each individual. Besides assisting in walking, rehabilitation support robots play other important roles. For example, when such a robot helps move the arms of a resident with a disability, the sight of the arm movements stimulates the resident's brain to enhance his or her functional recovery. Some of the residents who had moved into the nursing home in a wheelchair succeeded in training themselves to be able to walk unassisted again. Chie has seen these residents and their family members rejoicing with tears in their eyes.



＜Support for caregivers＞

Science and technology have helped reduce the burden on caregivers. Heavy labor that used to be done by caregivers, such as moving and lifting people in need of nursing care, is undertaken by robots. Currently, robots take on more than 10% of the caregivers' tasks. Additionally, because robots entertain residents of nursing homes and support their rehabilitation, caregivers can dedicate themselves to caring for those residents who are in greater need of assistance than others. When caregivers notice anything important about the residents they are caring for, the caregivers voice this information into a smartphone. The information sent via smartphone to a nursing care support system is sorted and forwarded to appropriate

personnel, such as nurses and staff of the nursing home's head office. The nursing care support system also creates nursing care logs and sends them to the families of residents. These logs are stored in the system's database and are used for smooth handoffs and communication among caregivers. They are also used for job analyses, based on which efforts are made to improve nursing care services. This nursing care support system has been fully utilized for prompt and efficient communication among persons receiving nursing care at home or at facilities, their family members, volunteers in local communities, staff at support centers, and primary-care doctors.

6 From Planning to Maintenance of Buildings

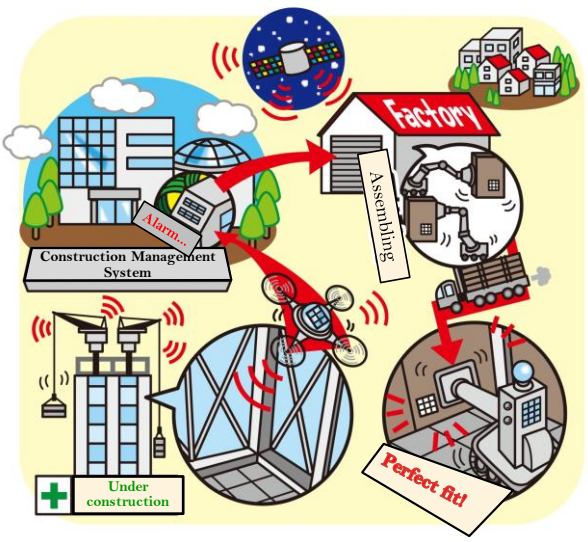
＜Making arrangements efficiently＞

Presently, Miki is responsible for designing a multi-purpose space where buildings will be constructed to house public institutions, business offices, leisure facilities and restaurants. Early on a Sunday afternoon, she is attending a meeting with local residents and others to finalize plans. In the meeting room, 3D images of buildings are projected on a screen. Questions from the attendees are answered by using the 3D images, and the design and the construction period are modified based on the sharing of specific images among the attendees. The consensus-building process has become much faster.

This efficient discussion process is made possible by the Construction Management System, which collates information on planning, designing, material procurement, construction and maintenance. This system automatically generates data necessary for computing the design and the required quantities of construction materials. Miki enjoys her job more than when she started, because she can spend more time developing new ideas for building features and creating beautiful designs for buildings.

＜Smart construction work＞

Plans have been finalized and construction work is about to start. A drone flies over the construction site, and high-precision measurements taken by the drone are used to create 3D drawings of the construction site as it is. The elevation differences determined by superimposing these drawings on 3D as-built drawings are to be accurately adjusted by self-regulating earthworks machinery.



After construction of the buildings starts, a flying drone monitors daily work progress and construction errors, which are minor but inevitable, at the construction site. Monitoring results are transmitted to the Construction Management System. In past mainstream work procedures, minor construction errors were corrected on site by adjusting the construction components that were to be joined together. Currently, robots operating at a construction materials factory integrate multiple construction components into one in accordance with the reported errors and on the basis of the 3D information provided by the Construction Management System. The factory is near a residential area. Because of the high-quality work

performed by robots, noise and dust from the factory are minimized, so no complaints have been received from local residents about the operation of the factory.

The construction components that were manufactured with consideration given to errors are delivered to the construction site at the required time and in just the right amount, so there is no need to secure storage space for these materials at the construction site. In constructing buildings, robots hold up heavy members and work with human workers to place and join these members.

Data on past industrial accidents is analyzed to identify hazardous locations at the construction site, and construction workers are alerted to the accident risk at these locations. It is reported that the number of industrial accidents at construction sites has been significantly reduced nationwide.

＜Support of maintenance＞

After the completion of buildings, small, energy-saving sensors that are attached to integrated or separate construction components send information on any deterioration or misalignment of components to the Construction Management System. The information from the sensors is accumulated and used to ensure the traceability of construction components. The Construction Management System provides various services to builders after their construction work is complete. These services include suggestions about the proper timing of construction components replacement and the reuse of construction components when buildings are renovated. The services provided by the system are highly appreciated because they enable the quick, efficient, energy-saving implementation of inspection and maintenance work with reliable methods even after severe earthquakes.

＜Extending the service life of extant infrastructure＞

A colleague of Miki is responsible for road, tunnel and bridge maintenance. He tells Miki that the quality of his work has improved, thanks to the Construction Management System, robots and sensors.

The development of long, thin, snakelike robots and of robots that can cling to walls by suction, and the advent of technology for long-distance, high-speed inspection of deterioration have made it possible to check sites that maintenance workers cannot directly observe. Deteriorated parts of structures at these sites can also be removed. The Construction Management System has accumulated data on the construction and use of roads, tunnels and bridges, on disasters that have affected these facilities, and on the history of inspections and repairs. Based on the data collected by inspection robots regarding deterioration of, and damage to, these roads, tunnels and bridges, the system determines the appropriate timing and details of repairs by taking into account priorities among these facilities.

7 Sharing of Various Systems for Disaster Prevention and Mitigation

Masashi works at the Disaster Control Center. He is responsible for issuing instructions to operators of rescue helicopters, emergency cars and vehicles that transport emergency relief goods after disasters. Nowadays, an increasing number of jobs do not require that employees commute to work. However, some people need to be on duty at all times at Masashi's workplace.

Masashi was a researcher on big data analysis technology when he was young. He feels that today's young researchers tend to be highly capable of doing research on big data, probably because they learned the basics of data analysis at high school and university. Three years ago, Masashi made a career change, leaving cutting-edge research to younger researchers. He chose his current workplace because information obtained through big data analyses is used there for the direct benefit of the public.

For the purpose of detecting disaster precursors so that residents can be provided with disaster forecasts as quickly as possible, a disaster monitoring system analyzes the following on a daily basis: meteorological and seismological observation data, images of the earth's surface acquired by satellites, gas components around volcanoes, and Twitter messages. Additionally, high-precision simulation technologies have been used to predict damage that is likely to be caused by disasters. Based on the simulations, specific measures have been examined to help minimize possible damage and maintain urban functions in the event of a disaster.

At the time of a disaster, information necessary for rescue operations and evacuation is analyzed. After a major disaster, soil, debris, inundation and collapsed buildings may make roads and highways impassable. Under such a situation, a wide variety of information is analyzed for the real-time creation and modification of disaster maps. The information used for analysis includes the following: information acquired by satellites, helicopters and drones; Twitter messages; information on building collapses predicted on the basis of data from the Construction Management System (cf. "6 From Planning to Maintenance of Buildings"); and vehicle location information from the Traffic Management Center (cf. "1 Purchasing Customized Goods and Friendly Services"). Additionally, personal information that is acquired by wearable devices and sent to the Center for the Protection and Utilization of Personal Information (cf. "4 Health care Management on a Daily Basis") is made available by the Center for analysis of the number of people in need of rescue and support, and their locations. The analysis results are displayed on the disaster maps at the Disaster Control Center.

At the time of the 2011 Great East Japan Earthquake, large numbers of helicopters flown by multiple

organizations achieved great results in rescuing victims. The Headquarters for Disaster Countermeasures and communicated by radio with each helicopter, but it was difficult for the pilots of these helicopters to share information with each other. Based on that experience, R&D has been promoted to ensure more efficient rescue operations. Presently, the geographical locations of helicopters and the details of their operations are displayed on maps at the Disaster Control Center. Information on helicopter locations and operations can be shared among helicopters as well as between the Disaster Control Center and each helicopter.

Thus, the Disaster Control Center can provide adequate instructions by referring to the locations of rescue helicopters and vehicles transporting relief supplies, to the current status of disaster-stricken areas, and to the locations of people needing rescue and support.

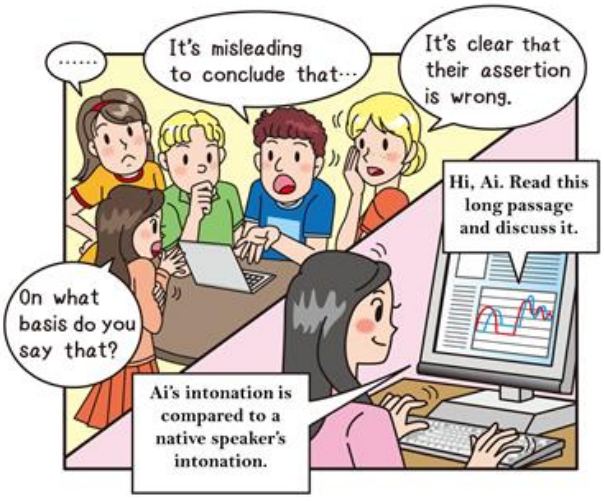
Anyone can view the disaster maps on the internet. Furthermore, citizens are guided to appropriate evacuation centers, as information on safe evacuation routes, temporary shelters and medical facilities is automatically sent to their smartphones and displayed on a map.

At ordinary times, the technique for locating people on the basis of the information provided by the Center for the Protection and Utilization of Personal Information is used for tourists. For example, for the purpose of identifying places where various tourists like to visit and to stay for a long time, tourists' behavior is analyzed according tourist attributes such as nationality, gender and age, and in the light of their preferred types of travel. The analysis results are used in providing tourists with various information services that advise them about sightseeing routes, souvenir shops and restaurants that they are likely to want to visit. Tourists can enjoy these services just by inputting their attributes and preferences in their smartphones.

In Section 1 above, Japanese society in the future was envisioned in line with the social issues identified in The 5th Science and Technology Basic Plan. With the advancement of science and technology, various aspects of our lives other than those described above will also change.

＜The lives of Ai and Theo＞

In 2020, when the Tokyo Olympic and Paralympic Games were held, the number of international visitors to Japan exceeded 40 million. The number has continued to increase since then, greatly surpassing 60 million. Now it is normal to see visitors from various countries not only in Tokyo but also in many other places around Japan. To support people from abroad who visited Japan during the 2020 Tokyo Olympic and Paralympic Games, automatic translation systems utilizing artificial intelligence were set up at airports, public institutions and facilities, and tourist areas. Visitors these days feel free to use automatic translation services in wearable devices or other mobile devices. The availability of these services has helped enhance Japan's attractiveness as a tourist destination.



Every time Ai has a discussion with international students in a seminar at university, she realizes many things. For example, although automatic translation systems are well developed, one's ability to directly communicate with others should be valued, and human qualities are important for communication. In the global society, the following are also necessary for people: directly sharing one's views and feelings with others in foreign languages while respecting the views and feelings of others; learning the differences between Japanese language and other languages, as well as the richness and profoundness of languages; and understanding that there is a diversity of languages, cultures, world-views and viewpoints.

Ai is in her final year at university. For the sake of her future career, she has been using an interactive artificial intelligence service to learn English since entering university. She is a busy student, so the interactive service is helpful to her because she can take English lessons at her convenience at home and because the lessons are tailored to the language skills and progress of each learner. She heard that an increasing number of users of this service are taking advanced courses. English education in Japan was enriched when Ai was in elementary school. Assistant language teachers at school are increasing in number now, and English lessons are given effectively by using digital teaching materials that make use of ICT. Consequently, significantly fewer Japanese than before feel reluctant to listen to and speak English.

At the elementary school that Theo, Ai's brother, attends as a sixth-grader, various efforts have been made in response to the rapid digitization of education. At that school, for the purpose of developing students' abilities to use information, active learning has been enhanced by utilizing ICT, including the tablet computers and electronic chalkboards that have been rapidly introduced into school education. Use of learning support software and ICT tailored to each subject has facilitated effective learning according to the needs of each student. Thanks to the experiences of learning by using ICT, students are motivated and encouraged to keep learning. Ai thinks that Theo is more active than Ai was as a sixth grader a decade ago in making preparations for school and reviewing lessons. In other ways, Theo is just like Ai was in elementary school, in that when he returns home from school, he opens the front door of their house only to leave his bag on the floor and immediately go out to play with his friends. Ai is not sure whether it is true that Theo spends time with his friends after school because he can finish his homework more efficiently than Ai was able to do a decade earlier.

It should be remembered that there are things only humans can do, although many things can be dealt with by using ICT.

＜Shun's hobby＞

There is one thing that Shun has been enjoying as a hobby for many years. It is railway model making. Now the Shinkansen (bullet train) directly links Hokkaido with Kyushu, and the Chuo Shinkansen Maglev Line recently opened to connect Tokyo and Nagoya. It seems that railway technology has reached the limits of speed increases.

When a long-distance sleeper train called the "Blue Train" was taken out of service about 20 years earlier, railway enthusiasts packed the platform to see it. This got a lot of TV coverage.

Shun has been adding to his collection of models little by little, chiefly collecting N-gauge[1] models of trains and railways that he became familiar with when he was a child and would travel on with his family. Model trains and railways were not constantly produced by manufacturers. Each model type used to be produced once every few years, and Shun had to wait for years until the models that had run out of stock were produced again. Some models were discontinued and went out of production, and he could no longer buy these. However, a service that provides railway data has made it possible to download 3D data for making models by using a 3D printer. Shun can create any model he likes by incorporating motors and other components. The data service provides detailed information about specific train sets, including data on the years and railway lines that these operated. Even small differences in the specifications of trains and railways can be identified.

Shun gazes with satisfaction at his collection of models on shelves. He reaches for the VR[2] system. To enjoy running model trains, Shun first had to create model railway dioramas. But VR systems are commonly used now, and Shun can enjoy the virtual experience of riding his favorite trains, including trains that have gone out of service. At his home, he has some dioramas that he created by himself. But when he wants to reminisce about the railway trips he took with his young children, he always uses the VR system to ride the rails.

1 Models that run on a 9mm-wide track
2 Virtual Reality

Column 1-2

1964×2020 (Color TV × technology for transmitting images of the entire sporting venue)

In 1964 Tokyo. Tokyo became a modern city with the opening of the Shinkansen (bullet train) line and the construction of expressways. Those significant changes to the city were prompted by the upcoming Olympic Games that were to be hosted by Tokyo. The selection of Tokyo to host the 1964 Olympics bought hope to a Japanese public that had been overwhelmed by a sense of loss after Japan's defeat in World War II. Japanese were able to regain their self-confidence. By taking advantage of the Olympics to show the world how Japan had recovered from World War II and achieved remarkable development, Japan was able to gain momentum for further economic growth. When Tokyo hosts the Olympic and Paralympic Games in 2020, about half a century after the previous Tokyo Olympics, what changes will have taken place in our everyday lives? This column looks back on Japan's social circumstances in 1964. In line with advances in science and technology, changes that Japanese society is likely to have undergone by 2020 are also forecast.

The 1964 Tokyo Olympic Games were telecast internationally by satellite, the first such Olympic telecast. Because of the innovative television technology used for telecasting, these games were also called the world's first "TV Olympics." The color television transmission system that began to be used in 1960 in Japan was used for live color telecasts of the games. The telecast of the 1964 Olympics demonstrated Japan's advanced telecasting technology to the world, and color TV sets rapidly became popular among Japanese consumers[1].

Efforts are being made to realize the real-time transmission of images that give an ultra-realistic sensation--a "sense of being there"--by 2020.

The feeling of being at the stadium no matter where you are in the world

The Concept of Immersive Telepresence "Kirari!"

Source: NTT

Nippon Telegraph and Telephone Corporation (NTT) has been conducting R&D on the immersive telepresence "Kirari!", with the aim of providing the public with real-time, ultra-realistic experiences of events held at remote sites so that they can feel as if they were there. For example, images of athletes are transmitted and displayed as life-size images. Other information on the event site and the like is also transmitted in formats that are appropriate for reconstruction using projection mapping. Toward realizing this service, NTT has been conducting R&D to address the following technical issues.

1. Increasing the precision of techniques for real-time extraction of visual and audio information of athletes from large amounts of information at the venue of a game
2. Synchronously transmitting the extracted visual/audio information and other real-time synthesized information (e.g., full images of the venue, sound at the venue, etc.,); reconstructing video images of games that are highly realistic at locations far from the venues

Toward 2020, NTT aims at providing a service that makes it possible for many people living far from sporting venues worldwide to view the real-time performances of athletes so that these people can share the sensation of watching sports and are impressed with how fast or high athletes can run or jump. For this purpose, NTT utilizes its immersive telepresence technology "Kirari!," which enables information on an entire sporting event site to be transmitted to multiple places far from the event site for reconstruction of the event as a whole. NTT is also working on a plan to use "Kirari!" to provide people with the ultrarealistic experience of viewing regional festivals designated as intangible cultural properties, traditional performing arts and live events that many people cannot experience firsthand due to the need for long travel.

1 White Paper 2015: Information and Communications in Japan