Best Engine

Vol. 6

Special Feature

Venturing into the Possibilities of Quantum Computers

ITOCHU Techno-Solutions Corporation

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Cover photo by
Masataka Nakano

Mejirozaka Data Center is located in an area of Tokyo known for its resilience against disasters. It is not only equipped with advanced security but is also an environmentally-friendly data center, including measures to reduce noise or to boost energy-efficiency. The power-supply facilities all have N+1 redundancy, and power can be secured during main power outages for 10 minutes using the uninterruptible power supply (UPS).

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The Four Seasons of IT

Transformation

Today, a wave of transformation is starting to spread again in Silicon Valley. It includes digital transformation, IT transformation, security transformation and workforce transformation. In fact, various transformations came up as topics of conversation wherever I went recently in the Valley.

We spoke to you about digital transformation in the U.S. on these pages of Best Engine issued in January 2016. It has now entered a new phase that is best described with adjectives like “data-centric” and “data-driven.” Numerous companies, such as platformers, are analyzing the data that is being generated in large numbers, making moves that lead to the creation of new business models and services. Amid this kind of a trend, a virtual environment known as a container has become commonplace in app development, with Kubernetes becoming a de facto standard. Quantum computers, too, which cannot be matched by all supercomputers put together, are also on the way to being put to practical use as a data analysis tool. These are changes that took place in only three years.

The CTC Group’s FY2018-2020 Medium-Term Management Plan, announced on May 1, is dubbed “Opening New Horizons.” CTC will be driving digital transformation in Japan over the next three years and opening up new prospects together with its clients. What will be the view that we see when such transformation is achieved? Our hope is that it will be one for which everyone’s reaction will be “Yes! This is what we’ve been waiting for.”

Incidentally, as Silicon Valley leads the world in digital transformation, there are a few things that I see in the Valley that are showing no signs of change, no matter how many times I go there. They include the hotels that are not worth the room charges and the morning and evening traffic jams. There are also the many restaurants that make me wonder if the people there have no interest at all in food and eating. It makes me wish that the wave of transformation will arrive in these areas as well. I have still yet to find a restaurant that makes me think, “Yes! This is what I’ve been looking for.”

Satoshi Kikuchi
President and Chief Executive Officer
ITOCHU Techno-Solutions Corporation

Special Feature

Venturing into the Possibilities of Quantum Computers

Something that we are hearing more often these days is that an age in which quantum computers will enable the ultrafast calculation of any phenomenon is coming. What stage are quantum computers at, and what kind of a future will they create? ITOCHU Techno-Solutions (“CTC”) fellow, Hidetoshi Satomi, spoke with Professor Kohei Itoh of Keio University on the possibility of the arrival of such an age. Satomi has been on the frontlines witnessing the transformation of technologies related to computers and Internet businesses, while Professor Itoh, Keio Dean of the Faculty and Graduate School of Science and Technology, has continually been at the forefront of quantum computer research.

Coverage and text by Yuki Kondo

Special Dialogue

Kohei Itoh
Professor; Dean, Faculty of Science and Technology
Dean, Graduate School of Science and Technology
Keio University

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Hidetoshi Satomi
Fellow
ITOCHU Techno-Solutions Corporation

Kohei Itoh

Professor; Dean, Faculty of Science and Technology
Dean, Graduate School of Science and Technology
Keio University

Graduated from the Keio University Faculty of Science and Technology, Department of Instrumentation Engineering in 1989. Obtained a Ph.D. in Materials Science and Mineral Engineering in 1994 from the University of California, Berkeley. Fellow, Lawrence Berkeley National Laboratory; research associate at the Department of Applied Physics and Physico-Informatics within Keio University's Faculty of Science and Technology, later becoming an instructor, assistant professor, and, in 2007, a full professor. In his current positions since 2017.

A Special Machine Like a Spaceship

H. Satomi: Moore's law says that the number of transistors in an integrated circuit doubles every 18 months. A well-known projection in IT circles, Moore's law has supported the IT industry for many years—that is, through the fact that performance has actually been advancing as projected by Moore's law, fueling expectations that computer performance will keep on improving. However, some are starting to whisper in these past few years that Moore's law is coming to an end due to physical limits.

Amid such circumstances, technologies that have the potential of greatly changing computing performance are GPU and quantum computing. GPU computing is general-purpose computing carried out on graphics processing units. It is already exhibiting superior performance in parallel computing, and artificial intelligence and deep learning. It is pretty much already at the stage of being put practical use. As for quantum computing, a Canadian venture firm has already released a commercial quantum machine, and IBM, Microsoft, Google and others are also engaged in developing quantum computers. Quantum computing-related developments in the IT industry seem to have been gathering momentum in the past year or two.

Keio University opened its Quantum Computing Center in April this year as a forum for industry-academia partnership in the field. Can you tell us about the quantum computer being researched at Keio University?

K. Itoh: I was originally involved in the research of silicon, which is a semiconductor. Silicon has three isotopes*[1], but the only isotope with nuclear spin as a property is the silicon-29 isotope. Like a magnet, it can have one of two states—spin up or spin down. It was about 20 years ago that the concept arose to realize a computer that could carry out calculations in single-atom units by embedding that silicon nuclear spin into a chip and assigning a zero or one digital signal to the spin up or spin down state. But, because individual atoms behave in accordance with the laws of

*1 **Isotope**
An isotope is a variant of the same chemical element but with a different number of neutrons. For example, silicon (atomic symbol Si; atomic number 14) has three isotopes (stable isotopes) with neutrons numbering 14, 15 and 16. Their respective mass numbers (number of neutrons + number of protons [atomic number]) are 28, 29 and 30.

Hidetoshi Satomi

Fellow
ITOCHU Techno-Solutions Corporation

Joined ITOCHU Techno-Solutions in 1988. Involved in the development and construction of large-scale systems for data communication networks from the early days of the mobile Internet. Contributed to the widespread adoption and expansion of Internet use in Japan. Has been supporting CTC's technology strategies and innovation as principal. In current position since April 2018.

quantum mechanics, its state does not become either zero or one. It can also become both zero and one at the same time. This is known as a superposition of states. In other words, the computer inevitably becomes a quantum computer. I later thought, well if that's the case, then I might as well carry out research on quantum computers.

As I proceeded with research, I found that a quantum computer lined with individual silicon atoms was not realistic, so I started thinking in a way that is closer to my current concept for quantum computers. It was in 2015 that I succeeded in placing individual electrons on silicon, and we successfully made a 2-quantum bit computer (quantum bits, or qubits, will be explained later). We later considered shifting the focus of our research to software, but it was around that time that IBM announced its "IBM Q" quantum systems, which can be said to the first step toward quantum logic gates*2. Keio University decided to participate in a project that would enable external parties to use the IBM Q. We are now at the stage where we are about to implement the project at our Quantum Computing Center.

H. Satomi: I get the sense that it is essential to know about quantum computing if we are going to look at information technology as it will be five or six years from now. However, no matter how much I study quantum computers with interest, it is very hard for me to clearly visualize its concrete form.

For example, it is often written in the mass media that if realized, quantum computers will be able to easily solve various problem that are virtually impossible to solve using classical computers because the calculations will take too long. However, we don't know specific ways for doing so nor are there yet any case examples. So, I'd like to ask whether it will really become possible to solve such problems using quantum computers. Also, what is the current state of quantum computers, and what kinds of possibilities do they contain?

K. Itoh: I can only say that we don't know what can actually be done using quantum computers. To say at this time that this or that can be solved using quantum computers would contain overestimation. Quantum computers are by no

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*2 **Quantum logic gate**

There are currently two types of quantum computing. One uses quantum logic gates, which is the method that has been traditionally envisioned. It follows the line of thinking used in classical computers of logic circuits. However, as the realization of a quantum logic gate seemed to be nowhere close to happening, Canadian venture company D-Wave Systems utilized the quantum annealing method (that utilizes the phenomenon known as quantum fluctuation to obtain the targeted calculation result) and surprised the world by suddenly completing a commercial quantum computer. Google and NASA (the U.S. National Aeronautics and Space Administration) have actually adopted the use of this computer. Meanwhile, IBM, Microsoft and others are advancing the development of quantum computers that use the quantum logic gate method.

Wafers (a thin slice of semiconductor material on which integrated circuits are formed) with a layer of only silicon-28 isotopes are made in the laboratory. With reduced electromagnetic noise, they become the foundation for quantum computers. (Photographed at Professor Itoh's laboratory.)

means a panacea. They would be only one kind of computer among various others that exist according to use—personal computers, mainframes, supercomputers, and so on. I believe that quantum computers have the potential of being useful only in specific areas. If they were to be compared to a means of transportation that included, for example, bicycles, cars, ships, airplanes and spaceships, quantum computers would be the equivalent of a special machine like a spaceship. And, just as a spaceship could not replace a bicycle or car, we' re not talking about quantum computers replacing everything, including personal computers. If quantum computers could solve issues, they would be of use to humankind. The existential value of quantum computers would be enhanced if advances are made so that they can solve, one at a time, those special issues that cannot be solved at present using the performance capabilities of classical computers.

H. Satomi: Just as commercial space travel [is no longer a dream but] is starting to become a real possibility, it' s very exciting to think that problems that couldn' t be solved for a long time might become solvable, especially considering how the world would expand as a result. The use of quantum computers in drug discovery to solve molecular models for medicines is something that is often mentioned. Even if just that became possible, quantum computers would still bring about tremendous benefits to humankind.

Issues Related to Quantum Computers

——What is the difference in calculation methods between quantum computers and classical computers?

K. Itoh: Classical computers carry out calculations using digital signals called bits. Bits are binary digits that are either zero or one. Meanwhile, quantum computers carry out calculations using quantum bits, or qubits, that can also be a superposition of both zero and one. So, for example, with classical computers, "2 cubed = 8" can be expressed using three bits (001, 010, 101……). However, only one of those values can be expressed at a time. Meanwhile, if there are three qubits, then eight states can be expressed at the same time, and all the calculations can be carried in parallel. In other words, the calculation speed of quantum computers becomes explosively faster the greater number of qubits there are. For example, eight times faster than a classical computer if it' s a 3-qubit computer, 16 times faster if a 4-qubit computer, 64 times faster if a 5-qubit computer, and so on. However, there are numerous issues that must first be overcome if that principle is to be actually realized as a quantum computer.

H. Satomi: One of those issues is related to the stability of qubits, isn' t it? The information retention time of a qubit (i.e., decoherence time) is extremely short, so only a very small amount of time can be used for calculation. Also, once a calculation is carried out, it takes time for it to stabilize. This makes it very difficult to use.

K. Itoh: One of the major themes of my silicon research was exactly that—to make a qubit with a long information retention time (i.e., a qubit with a long decoherence time). In 2002, we achieved the world' s longest quantum information retention time*3, and we made significant advancement experimentally. However, a further breakthrough is necessary for it to achieve a practical level.

Another important issue is how to increase the number of qubits. The IBM Q system is currently the most advanced quantum computer that is open to the general public. In 2017, it achieved 20-qubit computing. Today, it has 50 qubits within sight. However, we also know, for example, that qubits in the tens of thousands are necessary to use Shor' s algorithm for prime factorization to carry out calculations faster than classical computers. This is because individual qubits are not complete, and for reasons of stability, seven need to be bundled together to make one qubit. But, in any event, it is essential that we increase the number of qubits into the hundreds and thousands going forward.

H. Satomi: Achieving qubits with long information retention times and increasing the number of qubits—these two points are probably the biggest hardware-related issues for the realization of quantum computers.

*3 **Achieving the world' s longest quantum information retention time in 2002**
In 2002, Professor Itoh and his group succeeded in demonstrating a nuclear spin decoherence (quantum information retention) time of 25 seconds for ^{29}Si nuclear spin qubit at room temperature.

The Quantum World – Expressed by "Probabilities" and "Phases"

H. Satomi: Meanwhile, aside from hardware-related issues, there are also many issues related to software that need to be overcome, aren't there? One of them is how to make algorithms for making quantum bit-based operations capable of processing the calculations required for the issue to be solved. The thinking behind quantum computers is completely different from the thinking for classical computers. We have to start by once abandoning the conventional thinking—that is, to express various phenomena as a mathematical formula that uses variables like XYZ, and then write up as a program for processing by a computer—that we have been using with classical computers. The thing is, we don't know very much about what we should do in its place. Isn't that so?

K. Itoh: With quantum computers, the data that will be the basis of the calculations is mapped on the qubit for each problem to be solved, and calculations are made after deciding the zero or one probabilistic weighting for each qubit. Furthermore, information is treated like waves in quantum mechanics. The concept of phases is also important here. A way of thinking that differs completely from the past must be used in how natural phenomena and social phenomena are interpreted and expressed as wave amplitudes or phases for calculation, as well as in how meaning is obtained from the results of calculation.

H. Satomi: Like superposition, phase is a concept that is not easy to understand. Perhaps it can be best described as superposition that exists when quanta are thought of as waves. We need to consider the phenomena wherein waves become stronger of weaker depending on how a wave is superimposed with another wave.

K. Itoh: The phase of a qubit can be displaced or otherwise manipulated. If you carry out calculations using multiple phase patterns and look at the results, the obtained results start to be aggregated as distributions. That is interpreted as an event that takes place in the world, and the results are evaluated, with one result thought to probably have such and such a meaning, and so on. Being based on the concept of probability means that there is more than one result—it's not fixed on just one result. We need to stop thinking that there is a fixed answer for a fixed input.

Nurturing People Capable of Quantum Thinking

H. Satomi: Today, we can experience the IBM Q through a cloud computing platform*4. If it's a very simple calculation, then you can experience doing it on a quantum computer. I did this, and my impression was that the experience would be a bit of a shock to those who have been working in the field of classical mathematics or computers because the approach is so different from what we've known.

K. Itoh: I think that people who are skilled in mathematics would probably be able to handle the task of replacing the kinds of mathematical formulas that we write with a quantum program, which has another level of flexibility added on. However, I think that it would be very difficult to think of how to take that and relate it to qubits unless you have been immersed in quantum computing concepts from a young age. In other words, for the development of quantum computers, it is essential that we nurture people who are "native" to quantum computing and are imbued with quantum thinking. One of the roles of the Quantum Computing Center, which was established at Keio University this year, is just that.

H. Satomi: Arriving with a blank slate, coming into contact with an actual quantum computer and having discussions on its use and results. Quantum thinking is probably acquired through that process of trying different things by "playing" with quantum computing, and a new paradigm would be created as a result. I think the true development of quantum computers will take place after that.

K. Itoh: And through it, I hope to see the younger generation discover ways of using quantum computers that we had never conceived. It would be wonderful if our hub could create that kind of a trend—people coming up with the idea that, for example, by doing this or that, an amazing calculation of such and such kind might be possible even without 1,000 qubits.

*4 **Experience the IBM Q through a cloud computing platform**
This is possible through the IBM Q Experience (https://quantumexperience.ng.bluemix.net/qx/experience). One of its characteristics is that calculations are carried out by dragging and dropping a quantum gate (operator) on a screen that has what looks like the five-line staff used in music.

A Desire to Prepare for the Quantum Age with a Long-term Vision

——We got the impression that the concrete development of quantum computers is now truly about to begin. What do you see taking place going forward?

K. Itoh: Frankly speaking, we have no idea of the specifics regarding how things are going to develop, or how long it would take. On that assumption, if I were to venture an answer, I think that the first thing that would happen would probably be that we find a way that conforms to quantum mechanics for solving problems in micro fields. Mr. Satomi mentioned earlier that quantum computers might be utilized in the field of drug discovery. That is related to the fact that this is a field that handles the world of atoms, which follows the rules of quantum mechanics. My hope is that it then becomes capable of elucidating our macro world—in other words, the "classical" world that we intuitively understand.
H. Satomi: I feel that IT firms like CTC need to prepare for the age of quantum computing. Today, much of the focus of the IT industry is on the verification and discussion of artificial intelligence and the Internet of Things. Companies are at the stage of making advance investments in AI and IoT, inclusive of toward the resolution of social problems and enhanced effectiveness in business. Going forward, quantum computers will probably become one of the options for advance investments.
K. Itoh: The development of AI is indispensable for quantum computing. We are said to be in the midst of a third artificial intelligence boom. New development is progressing, hand over hand, in the field of AI. Eventually, though, we will run out of things that can be done using classical computers. To advance to the next level, we would probably need a computer that follows a new paradigm, and I would like that to be quantum computers. For that and other reasons, we need to develop both the tangible and intangible elements of quantum computing.
H. Satomi: There are always many problems at hand that companies should solve. We must continually find the means required to do this. When doing so, it's important that we find one that can be applied to more than a single field and can be used to solve problems in various fields. In this sense, I think that in a few decades, there is a strong likelihood that quantum computers will be at the center of this. CTC will look ahead into the future, and, while valuing "playing" in a good sense, we will launch a challenge into the new "quantum world" so that we can continue to identify the best IT solutions.

Enriching Society Through Materials: Expectations for the Application of Nanoscale Materials Analyses

The development of materials, whether it be self-repairing plastic, hydrogen energy or biomaterials, is indispensable for the realization of an affluent society. Here is an introduction of new CTC initiatives that are based on trends in materials development and have a focus on nanoscale materials analysis technology, which has been gathering momentum in recent years.

Science & Engineering Systems Division
ITOCHU Techno-Solutions Corporation

Hiroaki Kobayashi (On left)
CAE Solution Sales Department

Kazuki Mori, Ph.D. (On right)
Application Services Department

Materials Analyses that Contribute to Society

As a technology for the realization of an affluent society, attention is being focused on the development of new materials that will contribute to any field, whether automobiles, energy, healthcare or medicine. The development of new materials began in ancient times with alchemy, then went through the industrial revolution, and progressed to the development of materials in such areas as metals, ceramics and macromolecular materials (polymers).

The specific gravity, elasticity, conductivity, heat resistance, heat conductivity and other properties of a material can differ greatly depending on its crystalline structure or the combination of the elements that are linked together. In materials analysis, attributes related to electricity, heat and so on are derived from combinations and structures using calculations and simulations, which shorten the time required to create materials with superior performance or durability.

Progress in Materials Analyses

Materials analyses are supported by calculation methods and computer performance. Calculation methods differ greatly depending on the scale of the target structure being analyzed. Analysis of a material that can be seen with the naked eye is known as macroscale analysis. Approaches that are used in macroscale analyses include the finite element method, which finely subdivides the target structure being analyzed and creates models, and the homogenization method, which ignores microstructures. Meanwhile, experiments are not used in nanoscale analyses, such as the analysis of atoms and molecules. Instead, first-principles calculation and molecular dynamics calculation, which are based on quantum mechanics, have been established for the analysis. However, first-principles calculation requires computational effort that is, in proportion, the cube of the number of atoms involved. Therefore, massive computer resources are needed to analyze a practical number of atoms.

With the development of computing technologies like parallel computation, graphics processing units (GPUs) and cloud computing, it has become possible in recent years to handle analyses in micro units of space and time. Nanoscale materials analyses are starting to be noticed. Furthermore, with advancements in computers, a field called materials informatics has also come to the forefront. Data sciences technologies, such as big data and machine learning, are utilized in materials searches through the analysis of massive amounts of data related to the physical and chemical properties of substances and materials.

A representative case example of materials informatics is the Materials Genome Initiative—a U.S. federal initiative that was launched in 2011. The objective of this project is to reduce the time and cost of materials development. While also stimulating biological genome analyses, a development platform for new materials is formed by utilizing computational analysis technologies.

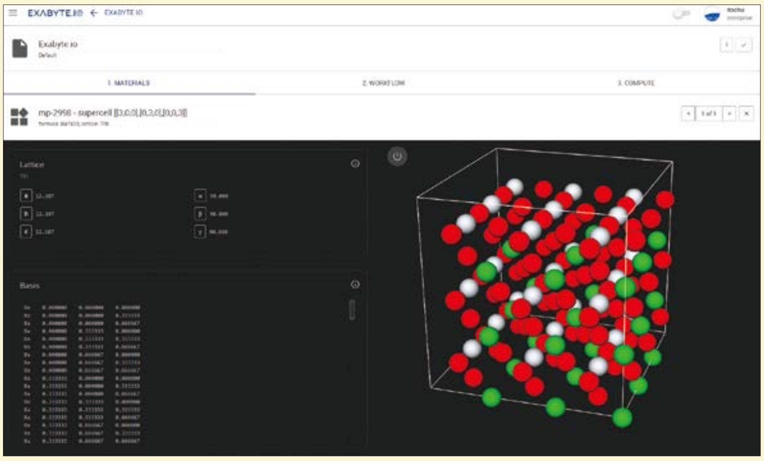
There are also expectations for the application of quantum computers—the development of which has been picking up steam in recent years—for the analysis of molecular structures and chemical reactions. There will probably be significant progress in materials development after they come into practical use.

CTC' s Materials Analyses Solutions

CTC has been involved in materials analyses for more than 30 years. From simulations of the various properties of microstructures based on thermodynamics, which are at the center, to the prediction of macroscale mechanical properties, CTC offers multiscale materials analyses solutions, including consulting and support.

For micro and macroscale analysis, CTC offers Thermo-Calc, which is software for calculating thermodynamic equilibrium, phase diagrams, and so on, centering around the field of alloys. There is also MICRESS, which is software used to simulate the evolution of microscale structures, such as alloy solidification and solid phase transformation.

■Image shot of an Exabyte.io screen



● Thermo-Calc

This is an integrated thermodynamic calculation software developed by Sweden' s Thermo-Calc Software. Through the utilization of various thermodynamic databases, Thermo-Calc can be applied to thermodynamic calculations in various fields, including alloy development, materials science, metallurgy, semiconductor development, (inorganic and organic) chemistry and geochemistry.

● MICRESS

MICRESS, or the MICRostructure Evolution Simulation Software, developed by Germany' s Access e.V., calculates the process of alloy formation using the multiphase-field method, which calculates the evolution in time and space of multiphase, multigrain microstructures through thermodynamic driving forces.

Exabyte.io, a Nanoscale Analyses Cloud Platform

In regard to nanoscale analyses, CTC embarked on the development of an analyses service from around 2015, including the expertise accumulated through micro and macroscale analysis of materials. In 2018, we began handling Exabyte.io, a cloud service that supports the nanoscale design and development of materials through analyses and modeling related to the physical properties of solids. Exabyte.io, provided by Exabyte of the U.S., can be operated through a web browser. Users are charged in accordance to usage, so the service helps reduce investments in analyses systems and software. Computer resources can be flexibly increased or reduced according to the calculation load, so the service can be used for calculations that pose a high load on a system.

The aforementioned Materials Genome Initiative provides the Materials Project, an open, large-scale database comprised of the results of first-principles calculations of crystalline structures and phase diagrams. Exabyte.io is also linked to this database. All crystal data related to a particular element can be obtained by simply entering the element name. There are workflows and modelers available for the analysis of various properties or the clarification of mechanisms. Therefore, a significant reduction of analysis time can be expected. It also includes functions to store calculation data and simulate physical properties through machine learning.

Cloud-based solutions like Exabyte.io will probably become mainstream going forward in nanoscale analyses as such analysis requires massive calculation resources. Because the materials of focus differ between the U.S. and Japan, CTC is also participating in the development of new Exabyte.io functions that utilize the nanoscale analysis technology fostered by CTC as well as accumulated data.

The Need for a Multiscale Approach

Now that nanoscale materials analysis is in the practical stage, there will be a need going forward for an approach that integrates various scales. Professor John Allison of the University of Michigan in the U.S. is proposing integrated computational materials engineering (ICME) in which information regarding materials development is integrated to form a collaborative model of multiscale data. Though its realization is still in the future, materials development will probably be even further accelerated as research progresses.

In 2017, CTC, too, developed a multiscale calculation solution, the theme of which was the casting and rolling of steel. It utilizes macro and microscale homogenization method calculation and the finite element method as well as nanoscale molecular dynamics calculation and first-principles calculation. Going forward, CTC will upgrade and enlarge its nanoscale analysis technologies and multiscale analyses solutions to contribute to the realization of an affluent society through the creation of new materials.

Technical Report

People and Organizations for a Digital Society — Educational Innovation Through Industry-Academia Partnerships —

Technological progress in recent years has enabled an industrial revolution that utilizes data, making digital society a reality. We take a look at the kinds of people and organizations that business will need to achieve growth as new value is created, and existing business models become inapplicable and are destroyed.

Norifumi Nomura, Ph.D. (Mathematical informatics)
Principal

General Manager, Business Development Division
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What Is a Digital Society?

While definitions of a digital society differ from person to person, it can be broadly defined as a society in which cultures, industries and people's lifestyles are changed through the creation of new business value resulting from the digitization (i.e., dematerialization) of physical items and services.

The driving force behind the advent of a digital society is the technology of recent years. Technological advancements in sensors and devices are digitizing the state of real society. High-speed telecommunications and capacity enlargement of memories and disks have made it possible to use the digital information stored within for the collection of big data. Furthermore, improved computer performance has made analysis of vast amounts of big data possible. With this came the development of artificial intelligence technologies, such as deep learning. An industrial revolution that utilizes data is now progressing in this manner.

The New Mechanisms Required by a Digital Society

In a digital society, new value is created when diverse groups become connected. Open innovation is the mechanism that is required for this. Open innovation is composed broadly of the following four elements.

- Business model

Transforming the revenue model by increasing business value through not only technological innovation but also the utilization of technologies brings about a new business.

- Ecosystem

A new mechanism in which academia, public agencies and companies are connected, and funds and motivation circulate among them becomes important. With new technologies being created again through such circulation, a growth cycle that supports digital society results.

- Development platform

Digital society changes at a rapid pace and the technologies for creating value will keep on evolving. A mechanism that enables swift launch and speedy customer feedback will be necessary.

- Data platform

The essence of digitization is data. A mechanism for data utilization (i.e., data collection, analysis and utilization) is fundamental. In particular, data sciences for the analyses of massive amounts of big data can be said to be most important.

Organizations and People for a Digital Society

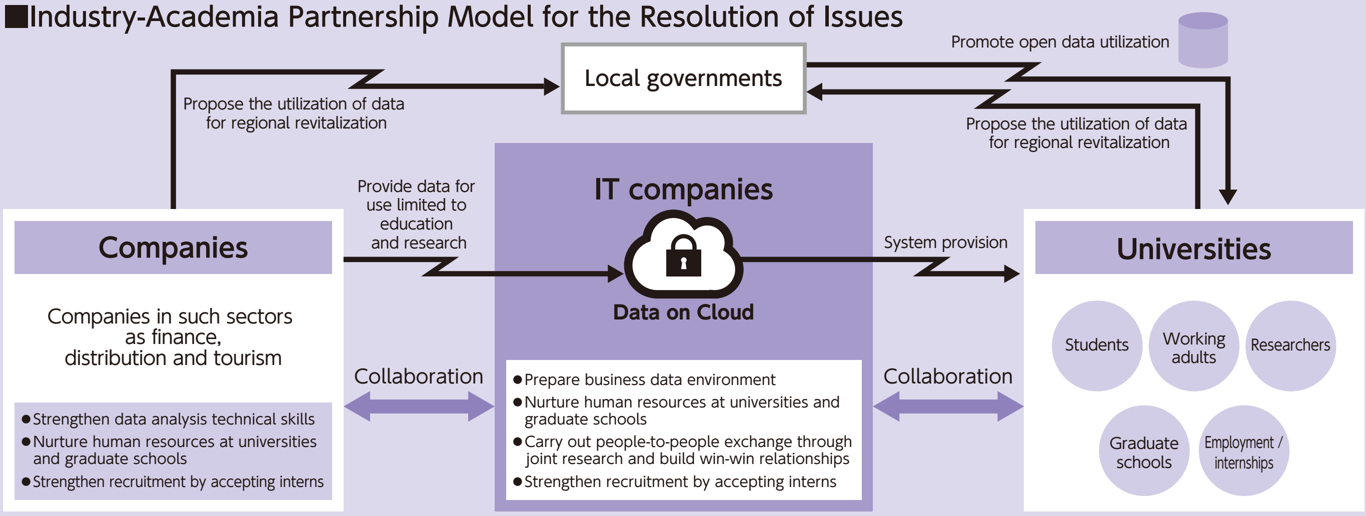
Much of digital businesses will differ from the form that existing businesses take. There will be a need to change from traditional organizations into new organizations (see Table 1).

Table 1　Traditional Organizations and Desired Characteristics of Organizations in a Digital Society

Traditional Organizations	Desired Organizations in a Digital Society
Organizations that are vertically divided according to responsibilities and KPIs	A flat and open group
Careful planning / waterfall model	Flexible response / agile
Mass manufacturing	Mass customization
Efficiency-oriented	Creativity-oriented
Thinking emphasizing "things"	Thinking emphasizing experience
Controlled	Autonomous
Expertise and uniformity	Soft skills and diversity

Digital business designers, digital engineers and data scientists are in demand as personnel who will promote the open innovation described above. A

■Industry-Academia Partnership Model for the Resolution of Issues



future digitized society can probably develop if the three kinds of personnel can form teams and work together as one.

● Digital business designers

They are personnel who plan and promote a digital business. In addition to business design capabilities, they need to have the capability to design the customer experience. Therefore, they need to train regularly to hone their observation skills and perceptiveness. Furthermore, they also need to acquire skills in collaboration and facilitation so that they can work with internal and external experts to create an ecosystem.

● Digital engineers

They are personnel who will design and implement mechanisms and system architectures that utilize digital information. In addition to technical skills, they need to have the capacity to understand the customer experience as well as people-centric designs so that they can grasp what is needed.

● Data scientists

In addition to skills in data analysis, data scientists need to have the ability to understand matters in the business setting so that they can identify, from digital data, the causes of social problems or factors for the sophistication of business.

A Mechanism for Human Resources Development Through Industry-Academia Partnership

A key to nurturing and developing such human resources is industry-academia partnership. Because digital engineers can probably be nurtured by making small changes to conventional development frameworks, here, we will look at nurturing digital business designers and data scientists.

1) Digital business designers

With the exception of educational institutions, such as design schools, that specialize in design, there are probably extremely few places that consciously nurture the ability to gain insight into the customer experience or to bring about innovation.

In recent years, much education for innovation, including design thinking, have started being carried out at companies. Furthermore, schools are testing active learning, which involves individual students to a greater extent. However, a place to carry out thinking training and a systemized program is necessary to nurture innovative human resources. Therefore, the cooperation of universities, where systemic theories can be researched, and companies, which are actually trying to bring about innovations, is necessary.

2) Data scientists

Data driven thinking has not taken root in Japan, and there are very few data scientists, who can think mathematically or carry out data analysis and utilization, present in Japanese society.

While an issue at universities is the difficulty of obtaining big data that is used in actual business, the issue at companies is that they have extremely few personnel who can educate others about mathematical models, mathematics or statistics. Resolving each other’s issues will be an important outcome of industry-academia partnerships.

CTC has concluded a cooperation agreement with Shiga University with the objective of promoting industry-academia partnerships and human resources development in the field of data sciences and is working toward the development of data scientists.

To make the digital society of the future one filled with dreams and abundance, what we need to do right now is to work to create value through open cooperation.

DIGITAL

This issue's theme is…

【Artificial Neural Networks】

Artificial neural networks support the foundation of artificial intelligence, including advanced image analysis. But what exactly is it, and how is it related to machine learning and deep learning? This is a look at how it works.

Text by Yuki Kondo

Mathematical Models Inspired by and Imitating the Human Brain

Human beings can decipher handwriting or see photos of something shot from different angles and recognize that they show the same thing, and we do this automatically without giving it thought. However, it is not easy for a computer to do the same thing. When using conventional methods, a massive program that gives a very large number of conditions and examples has to be written just to enable a computer to decipher, say, a handwritten letter "q."

Thanks to the 110 billion or so nerve cells, or neurons, in the human brain, human beings can carry out with ease information processing that is difficult for computers to do. The neurons in the human brain interconnect with one another to form large networks known as neural circuits. Advanced information processing is carried out and determinations are made through the exchange of electrical signals. (See the top half of Fig. 1.)

Would it not be possible to give computers the same kind of capabilities as a human being if a similar mechanism could be replicated on a computer? That was the thinking that led to the development of the mathematical model known as artificial neural networks (ANNs).

Just as the human brain's neural circuit is composed of a collection of neurons, ANNs are composed of artificial neurons. (See the bottom half of Fig. 1.) And just as neurons receive electrical signals through branched dendrites and output the signal from one long axon, artificial neurons have a number of inputs and one output.

Weighting and Threshold

To serve a role that is similar to human neurons, two types of numerical values are involved in artificial neurons. One of them is the weighting ratio, which is used for the weighting and summation of different information that is input. The other is the threshold value that is necessary to draw meaning out of the summated information. These two values enable artificial neurons to build models for making various determinations.

Here is a simple example of a model for determining whether or not a scenery in a photograph is that of a major Japanese city. In this example, the following three conditions are used to make the determination.

a. There many signages in Japanese
b. There are many people in business suits
c. The proportion of buildings is greater than the proportion of trees by two times or more

If "yes" for a., b. and c., then "1" is input respectively to the artificial neuron, and "0" is input respectively if "no" for all three conditions. Also, each condition is weighted, with "a" given the most weight, and the ratio is made "5:3:2." The threshold is set at "6."

In this example, if there are many signages in Japanese (a.=1), few people in business suits (b.=0), and there are twice as much or more buildings than trees (c.=1), then the value derived from this input is calculated as follows: 1×5+0×3+1×2=7. The answer is greater than the threshold of "6," so the determination made would be that the photo depicts a major Japanese city (the output would be "1"). On the other hand, if there are few signages in Japanese, even if there are many people in business suits and a large proportion of buildings (a.=0, b.=1 and c.=1), the derived value would be "5," which is smaller than the threshold. Therefore, the determination would be that the photo does not depict a major Japanese city (the output would be "0"). But what would happen if the threshold is set at "4"? It would change into a model in which a photo would be determined to depict a major Japanese city if there are many signages in Japanese, regardless of the other conditions. Meanwhile, even if there are few signages in Japanese, it would also be determined to depict a major Japanese city if there are many people in business suits and there is a large proportion of buildings.

This is a simplified explanation that has completely omitted any mathematical details. However, it shows that various models can be created for artificial neurons by changing the threshold or weighting.

Complex Determinations Become Possible Through Layering

As shown in Fig. 2, ANNs are created by linking a number of artificial neurons that have the aforementioned kinds of properties. In the figure, ● represent artificial neurons that are present in different layers. Various information is input from the left side of the figure as "0" or "1." The artificial neuron then carries out calculations like those shown in the example above and sends an output value of either "0" or "1" to artificial neurons in the next layer to the right. Various conditions are considered in this way and either a "0" or "1" is ultimately output from that layer on the right.

The greater the number of layers between the input and output, the more complex the determinations made become. In the aforementioned example, the "yes" or "no" response to condition a., "There are many signages in Japanese," can be divided into more detailed, multiple conditions, such as "The majority of the writing on the signage is in Japanese," or "The road signage is written in Japanese," and the determinations made after deciding the weighting and threshold. Dividing up individual conditions into more detailed conditions – that is to say, by increasing the number of layers in the ANN – makes it possible to construct a model for carrying out a determination after considering even more elements.

As for the crucial weighting and threshold, the ANN will optimize the setting by being fed large quantities of data and "learning." Such learning can take two forms. One is supervised learning in which the correct, or desired output value, is taught along with the fed data. The other is unsupervised learning in which no desired output value is taught. Only large quantities of data are provided, and the machine "thinks" for itself using no guidance. Whichever method is used, the ANN will seek and find more appropriate weighting and threshold values.

These are the principles that enable human-brain-like determinations and decisions to be made by computer using ANNs.

Overcoming Technological Challenges for Development to a Higher Level

ANNs are a technology that is indispensable for the development of artificial intelligence. On the other hand, when speaking about artificial intelligence, we hear words like machine learning and deep learning as if they existed as pairs with AI. What are their relationships with artificial intelligence?

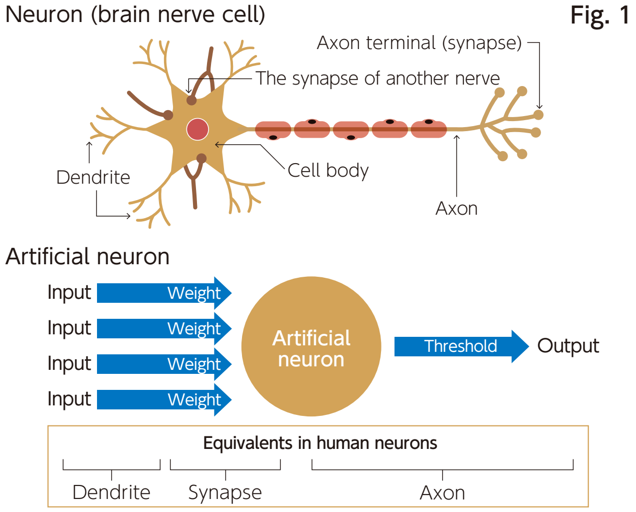
First of all, machine learning is one of the methods used in artificial learning to enhance AI capabilities by learning from data. ANNs exist as one machine learning method. Deep learning is machine learning in which there are many artificial neuron layers, creating a "deep" layer of conditions.

Research on ANNs began in the 1940s. However, research was suspended forced by such reasons as technological issues related to computers and insufficient amounts of data to be used for machine learning. It was only in the late 2000s that such issues were finally resolved. ANNs began to be applied rapidly in recent years in technologies like image analysis.

There are several types of ANNs, categorized by method and objective. One type of ANN is the convolutional neural network, or CNN, which is particularly useful in image recognition. Generally speaking, a single point on an image has a deeper relationship with other points in its vicinity as compared to distant points. This property is utilized in CNN to make more efficient calculations. Neural networks have also now evolved further with the appearance of capsule networks, which overcome the issue of an image being recognized as a different image if the image is rotated.

Artificial intelligence and the human brain—how much smaller will the gap between the two become going forward? Its future may be dependent on the evolution of artificial neural networks.

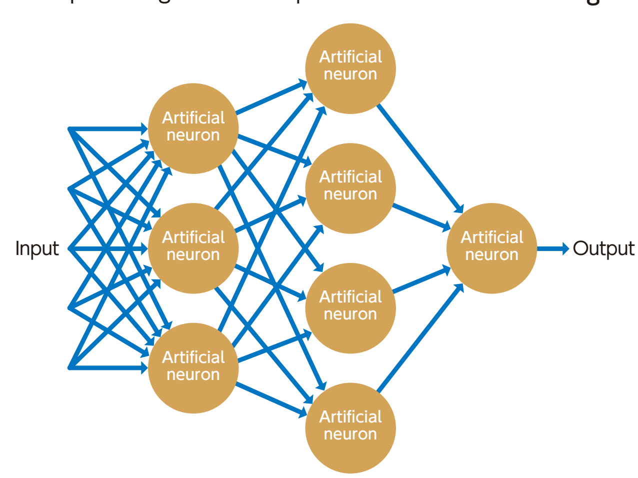
Fig. 1



[Reference] https://sitest.jp/blog/?p=6727

Electrical signals are input to neurons through multiple dendrites that extend from the outer edges of a neuronal cell body. These signals pass through an axon, which is a long, slender projection at the middle of a neuron, and are output to another cell from the axon terminal, or synapse, shown on extreme right in the figure. Like human brain neurons, artificial neurons also have multiple pathways for the input of information.

Fig. 2

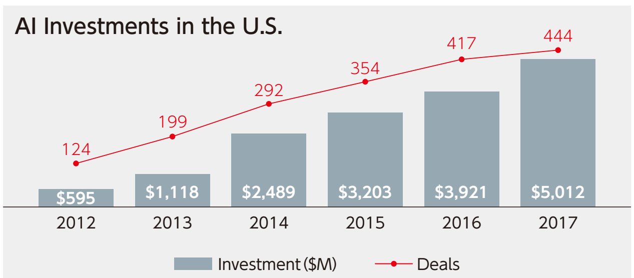


Information is input from the left side of the figure and processed in the layer of artificial neurons on the left. After being processed in this layer, it moves on to the layer in the middle. It is processed in a similar manner in this layer of artificial neurons, and the information is sent to the artificial neuron layer on the right from which it is output. There are multiple output arrows pointing out from the artificial neuron on the extreme left to indicate that the same output value is sent to numerous artificial neurons. The fact that there is only one output (value) from an artificial neuron does not change.

AI Everywhere

Junka Kaneda
International Business Development
ITOCHU Techno-Solutions America, Inc.
Surveys advanced technology and IT trends in North America, with a focus on artificial technology and big data, and refers to Japan, vendors that handle the latest technologies.

It was in 2011 that the oft-quoted phrase "Software is eating the world" was written in an essay submitted to the Wall Street Journal by prominent investor Marc Andreessen. It was a reference to how all industries were digitizing, and even those traditional industries that did not seem at first sight to have anything to do with information technology – bookstores, hotels, and taxis, for example – were transforming. Fast forward to 2017. This time, it was Nvidia CEO Jensen Huang who said, "Software is eating the world, but AI is going to eat software," at the GPU Technology Conference hosted by Nvidia. He explained that if software was going to transform the world, then, its driving force was artificial intelligence—that is, AI could be found everywhere. This has been shortened to "AI Everywhere." Other leading vendors, like Microsoft and Salesforce, also speak of the same kind of circumstance, referring to it respectively as "Everyday AI" or "AI for Everyone." Such vendors are embedding AI in products, making it possible for users to utilize AI without being aware that they are doing so. If AI becomes something close to and used by anyone, anywhere and at any time, the important topic to discuss turns from "What is AI?" to its application, or "What will be achieved through AI?"



[Source] PwC | CB Insights MoneyTree™ Report Q4 2017

Increased Investment in AI Applications

This trend can be seen not just in the initiatives being undertaken by major vendors but also in the investments being made in AI ventures. Investment in the United States in AI exceeded 5 billion dollars in 2017. This means that in the U.S., more than twice the amount of total investments made in Japan in venture firms is being made just in AI ventures. If you look even closer at the breakdown of AI venture investments, you see that in the past two years, investment in applications with AI functions was 3.8 times greater than investment in AI infrastructure (algorithms, libraries and hardware for AI). The research company CB Insights publishes "The AI 100," which is a list of the 100 most promising AI vendors. The companies in the list are focused around fields or applications in specific industries, such as FinTech, cybersecurity, education, healthcare, agriculture and news & media.

Need for an Understanding of Businesses Greater than Technological Capabilities

While investment and vendor activities focused around applications is booming, surveys have found that only a small portion of enterprises are actually able to proactively utilize AI. Various reasons are given as to why good use of AI is not being made. They include issues related to data science skills, budgets and data organization. However, the reason that is given most often is the inability to specify AI use cases. An argument that we hear often recently is that the gap between data sciences and business processes must be filled in order to apply artificial intelligence but doing so requires a knowledge of business that is equal to or greater than knowledge in technology. It is only with the knowledge of business that the most optimal use cases and KPIs can be formulated, the data that is required considered or legal compliance be achieved.

In this issue, we took a look at the phrase "AI Everywhere." In regard to Blockchain, which is under the spotlight recently, we are starting to hear the phrase "Blockchain Everywhere." Like with AI, the understanding of business – not just technology – will likely become essential in this field.

News Pickup

Here is information on solutions and services,
selected from CTC news releases, that are in the limelight.

Global

CTC Begins Offering IT Services in Europe

In a business alliance with Britain's Newton IT, which offers IT services in Europe, CTC is now providing total IT support for Japanese companies doing business in Europe. Newton IT has been providing system integration services in Europe for more than 20 years. The company now offers its services in 14 countries around the world, centering on Europe. Going forward, CTC and Newton IT will consider the provision of joint solutions in a wide range of areas, including the latest security, RPA and other applications as well as IT infrastructure solutions.

AI

CTC Invests in AI Startup Cinnamon Inc.; Will Contribute to the Business Efficiency of Clients

CTC has decided to invest in Cinnamon Inc., which offers AI solutions that utilize deep learning. There are major expectations held toward the application of artificial intelligence in various fields. Among them, Cinnamon possesses high-precision technology in the field of AI and optical character recognition (OCR), which converts handwritten and other text images into machine-encoded text. The company has developed and offers AI products that can "read" documents like a human being. CTC offers business process outsourcing (BPO) services that are linked with AI and robotic process automation (RPA) technologies. With this new link with Cinnamon products, CTC will contribute going forward to the further streamlining of client operations.

IoT / CIM

CTC Develops the "C-Series," Which Will Contribute to Productivity in Construction

CTC has developed the "C-Series," a software that automatically generates 3-D models used in construction and enables the visualization of construction processes. C-Series enables the real-time visualization of operations and circumstances, which were previously dependent on workers' senses and intuition, experience, visual perception and manual information entry. A service intended for foundation improvement, embankment and dredging work, the C-Series makes the sharing of information among concerned parties smooth. Going forward, the service will be expanded, with the use of cloud computing also in sight.

Big Data

CTC Concludes Cooperation Agreement in Data Sciences with Shiga University

CTC concluded a collaboration and cooperation agreement with Shiga University. The objective was human resources development in the field of data sciences and the promotion of industry-academia partnerships. Shiga University was the first university in Japan to establish a faculty of data sciences and is engaged in nurturing data scientists. CTC and Shiga University will share knowledge related to the analysis of corporate data and carry out joint research and development of practical educational methods that are as close to actual business as possible. The sophistication of the analysis of corporate data and AI development will be promoted through people-to-people exchange and demonstration experiments with Shiga University.

Cloud / Security

CTC Obtains ISO/IEC27017, an International Security Standard for Cloud Computing

CUVICmc2, CTC's cloud computing service specialized for mission-critical systems, obtained ISO/IEC27017 certification, which is an international security standard for cloud computing. This international standard expands the normal ISO/IEC27001 standard for an organization's information security management system (ISMS) for application in cloud computing services. Since its launch in 2016, CUVICmc2 has worked to enhance the quality of the service. The ISO/IEC27017 certification was obtained in recognition of CUVICmc2's security measures and system of operation.

Global / Agile Development

CTC Global (Thailand) Concludes Partnership Agreement with OutSystems

CTC Global (Thailand) has concluded a partnership agreement with OutSystems to commence agile development support services in Thailand. OutSystems Platform is for low-code app development and enables the development of applications with minimal coding. This partnership aims to enable Japanese companies and their local subsidiaries in Thailand to develop applications in a short amount of time. This is in response to the need for the standardization of development quality between ASEAN nations, including Thailand, and Japan, speedy application development and the trend toward mobile-first development.

Please visit the following for further details.

http://www.ctc-g.co.jp/news/

Golf Digest Editorial

Practical Golf Theory for Mental Toughness

(With the cooperation of Team Serizawa Golf Academy)

Nobuo Serizawa

Born 1959; age 58. A lifetime record of five Japan Golf Tour wins, including the Japan PGA Match-Play Championship (1996). One Japan PGA Senior Tour win marked since becoming eligible. Currently heads Team Serizawa, which he formed with professional golfers Hiroyuki Fujita and Katsumasa Miyamoto. Opened a golf academy at the Daihakone Country Club. Has many fans and followers and is known for his easy-to-understand golf lessons.

Pointers for Learning by Watching Golf Tournaments on TV

The Japan Golf Tour season is at about the halfway point. So, what do you focus on when you watch golf tournaments on TV? I think people tend to pay attention to who’s in contention and what’s happening on the leaderboard as well as the distances being hit by the pros. Actually, there are many pointers for amateurs contained in the tournaments for improving your game. Let’s take a look at them in this issue.

As a pro golfer, something that I would really like amateur players to use as reference are the rhythms and routines of the plays of pro golfers. The better the golfer, the more constant the routine they follow, and the more constant their rhythm is for each stroke. Regardless of whether their shots have been successful or not, they are not affected emotionally. They just go on playing coolly. This, in fact, is the biggest secret to keeping your score steady and constant.

Don’t Worry About Making a Bad Shot—It’s More Important Not to Let a Bad Shot Keep Affecting You

When I play with an amateur golfer at a pro-am tournament, I sometimes encounter golfers who get very upset for hitting a shot out of bounds, for example, and never recover from it no matter how well they had been playing before it. Bad shots are a part of life when playing golf. So, it is more important that you not let a bad shot affect you rather than focus on not making a bad shot at all. In fact, if you watch a golf tournament closely, you will see that even if a pro makes a bad shot, the pro will hit the next shot after following his or her usual routine. The sequence of steps a golfer goes through before taking a shot is called a “pre-shot routine.” Pros try to ensure that they keep their pre-shot routine constant. This is because following the same steps each time ensures that their focus shifts automatically to the shot in front of them, making it easier for them to exhibit their usual capabilities as practiced.

When a golfer makes a bad shot, they are often told to move on and put the bad shot behind them. However, the truth is that there is no emotional on-off switch that people can flip to control their feelings. So, Tiger Woods, for example, created a “Ten-second rule” for himself, which he followed after a bad shot or stroke. He would allow his emotions to explode and let himself be angry for just ten seconds. This was the psychological technique he used to switch emotional gears. By releasing his emotions and getting it out of his system, instead of suppressing anger or frustration, he was able to “forget” that bad shot and move on to his next shot unaffected. Unfortunately, it is not a technique that I can use. If I let my anger show, I think I would regret it and immediately wonder why I expressed my anger! (laughs) Following the same routine before every shot is a simple, effective strategy that can be used by anyone, so please make yourself aware of your routine and give this a try.

Female Pro Golfers Achieve Distance Using Their Flexibility More than Their Muscle Strength

Another thing that I would like amateurs to use as reference when watching a golf tournament is how good their shot efficiency is. There are more and more golf tournament TV broadcasts that set up the latest launch monitor on the teeing ground and display, on screen and in real time, tracked data of a tee shot. What such data shows, particularly in the case of female pro golfers, is the fact that despite a club head speed that is the same or slower than male amateur golfers, female pros achieve a carry distance of 230 to 240 yards. This is an indication of the great efficiency of the shots made by female pros. Conversely, it also reveals how much club head speed is being wasted by amateur male golfers. If you watch the golf swing of a female pro, I think you will understand that flexibility is more important than muscle strength in terms of shot efficiency. In particular, you need flexibility around the shoulder blade and hips to achieve a wide golf-swing-arc and maintain club-head speed. If you are a middle-aged or older man, I recommend that you make it a daily routine to stretch those areas at least, if not more.

Golf Clubs that Are Suitable for You Are Your Best and Easiest Clubs

Launch monitor data for male pro golfers also shows that more carry distance can be achieved today through a fade shot rather than a draw shot. A characteristic of contemporary drivers is that the direction that the balls fly depends on the angle of the club face at impact. This is because it is easier to achieve greater carry distance with the face slightly open and the force being placed straight towards the direction of the face as compared to forcing yourself to close the face to hit the ball straight on. The idea that draws are better for achieving distance is now not only outdated but also a mistaken assumption. We are in an age in which, whether a pro or an amateur, the most important requirement is that the golfer swings the club in a way that will bring out the best performance of the club being used.

As for choosing clubs, when I was aiming to become a pro golfer, the only way that I could make a decision on clubs was to go to a driving range and find one that "felt good" or "seemed" to be achieving distance for me. I had no way of knowing if I was really achieving good distances with that club until I actually went out on a course and used it in competition. Even after becoming a pro golfer, launch monitors were the exception rather than the rule in Japan. So, I used to go to Carlsbad, California, in the U.S. to have my clubs fitted. What I discovered at that time was that even though I preferred hitting lower-trajectory shots that rolled a lot after hitting the ground, the launch monitor showed that it would be more advantageous for me if I increased the loft and hit higher-trajectory shots. As a matter of fact, this strategy increased the carry by 15 yards. The thing is, because the height of my shots was completely different from before, it felt like I was not playing my style of golf. It took me quite some time before I got rid of that doubtful feeling. Today, of course, I would make changes to the specs without question if the data showed that things would be better! (laughs)

If you look at the recent equipment setups of pro golfers, you will see that even pros are using "easier" golf clubs. Female pros, for example, usually have a lot of fairway woods and utility clubs in their setup for use in the place of long irons. I think this is something that should be emulated by some amateur male golfers. In fact, using an easier club will help you improve your game faster.

Messages from Hikari and Misato Fujita

Professional and Amateur Golfers Supported by CTC

This year, CTC is rooting for female golf pro Hikari Fujita and her younger sister, Misato, who is giving her all to become a pro golfer. We asked them for their thoughts about this season as well as on their golf training, which they have been engaged in since they were toddlers.

Pro Golfer
Hikari Fujita

This season, my goal will be to first make the cut in those tournaments that I will be competing in, whether I entered it based on a recommendation, a Monday qualifier, or after being wait-listed*. In the latter half of the season, I will practice with a focus on qualifying tournaments. Now that I have had the operation on my elbow, I no longer experience the pain that I was having, and the distance of my shots are getting back to what it used to be. I am doing my best, with making a comeback as my aim.

Hikari Fujita—born 1994. Started playing golf from age 3 with her father as her teacher. Passed the JLPGA pro test in 2013. First win as a pro was the JLPGA Kaga Electronics Rookies Cup. Achieved her long-sought win in a regular tournament in 2015.

*Wait-listed golfers stand by on site and are allowed to play in a tournament if a scheduled entrant cancels his/her entry. The order on a wait-list is based on the golfer's qualifying tournament ranking for the previous season.

Misato Fujita

This year, I was eliminated after the first stage of the JLPGA pro test. This was a result that I had not imagined would happen. Now, I am reviewing what I need to do to pass next year's pro test and am practicing hard. Please root for me!

Misato Fujita—born 1996. Began golf at age 3 and has a personal best score of 69. Was in the limelight in the juniors, playing alongside her older sister Hikari, and the duo was always monopolizing first and second place in a tournament. Driven by her father's passing, Misato has been aiming to become a pro golfer since 2017. She's working toward passing the JLPGA pro test and qualifying tournament next year.

How the Two Sisters Practiced Since Early Childhood

We both started golf at age 3 with the encouragement of our father. We learned everything from him, starting with the very basics. We practiced every single day of the year without any time off. In the summer, we would hit 500 balls at the range as well as practice a round of golf. During winter, since we could not go out on the course, we would do things like hit 1,000 balls and do 1,000 practice swings. We also created a putter practice space at home by laying out an indoor putting green in one of the rooms, and we practiced on that every night. We also did some original training.

IT Insight

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This issue’ s number is...

30 minutes

The amount of time it takes an expert “AI physician” to find a genetic mutation

Precision medicine carries out not only highly advanced genetic analyses but also provides optimal treatment tailored to individual patients. It is in the limelight these days as a next-generation cancer therapy and is showing signs of establishing itself as practical healthcare.

Cancer has been one of the biggest challenges for humanity. Healthcare has been engaged in an uphill battle with this disease for a long time. However, cutting-edge gene decoding technology and artificial intelligence seems to have us at the dawn of a dramatic change in cancer treatments.

Today, state-of-the-art cancer treatments are making a change of course into healthcare that emphasizes the unique genetic mutations found in each patient’ s cancer. The identification of each patient’ s genetic mutation through gene analysis and the prescription of anticancer agents that have a significant effect on it, or healthcare that is optimized for each patient, is starting to become a reality. It has been known for some time that each cancer has a unique genetic mutation. However, it took time and great cost to analyze a patient’ s cancer cells to determine the genetic mutation, making it difficult to use as an ordinary form of medical treatment. Innovations in gene analysis technology, such as next-generation sequencers, has now made it possible to look very closely at genetic mutations while reducing time and suppressing costs.

In precision medicine, artificial intelligence plays an active role like that of an expert physician. Typically, physicians and researchers identify the genetic mutation in a patient’ s cancer cells and determine the treatment. However, massive amounts of data and materials must be analyzed, making this a strenuous task for humans. On the other hand, Watson for Genomics, developed by IBM, learns from an enormous amount of scientific papers – more than tens of millions, in fact – that a single person would be incapable of learning from. By entering patient data, the genetic mutation that should be targeted for treatment is identified and an appropriate anticancer agent proposed. It has been reported that a complete genome analysis of a colorectal cancer, which took humans one year to complete, was finished in only 30 minutes through the use of AI.

Of course, while precision medicine may seem to be an unmixed blessing, there are issues—that is, the high expense and insurance coverage. While some cancers are covered by health insurance, patients cannot choose what kind of cancer they get. The reality is that if it is not recognized as a treatment covered by their health insurance, then they will either have to pay an exorbitant price out of pocket – which can range from hundreds of thousands of yen to several million just for genetic testing – or take part in a clinical study.

In the United States, the costs for cancer gene testing is starting to be covered by Medicare (a public health insurance plan for the elderly) if the treatment has been approved by the U.S. Food and Drug Administration (FDA). It has been reported that there are hopes that this trend will help push private insurance companies to consider cancer treatments that utilize genetic testing as a standard method of treatment.

[Reference]
Gan Chiryo Kakumei no Shogeki—Pureshijon Medishin to wa Nanika? (What is precision medicine—the impact of the revolution in cancer treatments) by the NHK special group of reporters
https://www.cancer.gov/about-cancer/understanding/statistics
https://www.ibm.com/think/jp-ja/watson/watson-for-genomics-professor-miyano-interview/
https://wired.jp/2018/04/05/medicare-genetic-cancer-testing/

information

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http://www.ctc-g.co.jp/~CTC-BS/

CTC Business Expert Corporation (CTCBE)
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