Featured Articles

# AI for Taking on the Challenges of an Unpredictable Era

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## RISING INTEREST IN AI

ARTIFICIAL intelligence (AI) is a topical subject. Large investments in the technology, which is a major factor in international competitiveness, have been announced by governments and other organizations.

Nobody as yet has an overall grasp of what impact AI will have on business and other parts of society. However, new developments that give a glimpse of the future have already begun to appear. These can be found in marketing, academic papers, investment decisions, and Internet chatter. And they already include examples of how things will play out in the future. The future is already happening.

However, very few people have the opportunity to deal with these in their entirety. Business people find it difficult to understand technology and its significance while, for AI technologists, the world of business is far away.

The author's own life reached a turning point some 13 years ago when Hitachi's exit from the semiconductor industry meant that he was forced to abandon the semiconductor research he had been engaged in for the previous 20 years. While the company's decision was very unfortunate for him personally, he regrouped and made a fresh start along with his colleagues. This was a turning point because it enabled him to embark on research into what is now called big data and the Internet of Things (IoT), along with AI, before these became popular topics. It wasn't that he had any particular vision, it was more a matter of someone who had nowhere else to turn finding unexpected strength. Looking back, there is nothing for which he is more grateful than this decision by Hitachi to shut down its semiconductor business.

Thanks to these changes, the author now gives more than 500 lectures and other presentations on AI each year, providing opportunities to meet many different people and to discuss how AI relates to companies, business, and people. These range from lectures given to audiences of 1,000 or more to the board meetings of listed companies. The people he meets come from a wide range of industries, including many executives from the manufacturing, finance, retail, logistics, and public sectors.

Through these discussions he has been able to identify developments that, while still in their early stages, are already up and running and will have a significant impact in the future. This article describes the developments he has found.

## MISUNDERSTANDINGS ABOUT AI

Accompanying the recent rapid growth of interest in AI there have been increasing numbers of editorials and other commentaries coming out that the author finds disquieting. The following are statements that are commonly heard in relation to AI.

"Machines can now beat humans, even at the game of *go*."
"This will lead to competition between people and machines (AI)."

Both of these statements are misleading.

The science journal, *Nature*, carried an article about how the AlphaGo *go*-playing software developed in the UK defeated the European champion[1]. While computers have already beaten professional players of both chess and *shogi*, because the search space of *go* is orders of magnitude larger it was believed that victory would not come so easily. Nevertheless, computers have become triumphant in a much shorter time than expected. Because the software uses deep learning[a], a topical AI technique, it has been reported that AI has now surpassed human intelligence.

By contrast, the author sees this in terms of a battle between humans.

(a) Deep Learning
A machine learning technique that incorporates mechanisms from the neural circuits of the brain (deep neural networks). Like the brain, deep learning is designed to increase the weighting of circuits that produce correct answers and it can make judgments on unknown patterns, especially in images, by having the computer identify features on its own from input learning data.

On one side are those who adopt the traditional approach of improving their abilities through experience and learning. In other words, people who choose to compete using their own physical and mental strengths.

On the other side, there are those who choose to learn systematically from past records of games, using computers for this purpose, and then having these computers play against each other tens of millions of times to provide more data for learning. These people take a systematic approach to thinking about how best to take advantage of large amounts of past data and the overwhelming data processing and memory capabilities of computers, and apply their physical and mental strengths to this end.

In both cases, it is a human choice and the competition is one between humans.

As a result, those who have taken the latter approach have predominated. That is, success has been achieved by striving systematically to build computer-based techniques for tackling the problem of unknowns.

The reason for this is simple. It is because computer performance has improved and more data has become available to use for learning. This does not apply only to the game of *go*. The same thing is also happening in business.

An important factor for business in all of this is that the development team for the *go* program did not include anyone with professional-level skills in the game. The development of conventional business and management systems has required expertise in the relevant fields. By contrast, the systematic learning used by the computer described above did not require the people involved to have any special expertise. It is anticipated that, as greater use is made of systematic learning, the relative value of practical application-specific knowledge will diminish.

Instead, what is important is data. The value of business and other real-world data is growing rapidly. What is also becoming important is the ability to use computers to learn systematically from data.

To view this as a competition between humans and machines is to misunderstand what is happening. Despite the fact that new ways of solving problems through AI are driving rapid changes in what is required of people and in how they go about living their lives, there is a risk that they will adopt misguided ideas and actions by failing to recognize this.

Nobody would be surprised to hear that the track athlete, Usain Bolt, lost in a race against a motor vehicle. Likewise, the author has never heard anyone claim that their own knowledge is less than the results of a web search engine (which itself is a form of specialist AI). People are simply happy to make use of vehicles and search engines. And, by using the technology themselves, people will acquire an understanding and rid themselves of this unusual way of looking at the situation as a competition between humans and machines.

## NECESSITY OF AI

Use of AI as a new methodology is growing rapidly in business. This is because of the significant positive impact it has on productivity.

### 20th Century and Standardization

Peter Drucker predicted that “The most important, and indeed the truly unique, contribution of management in the 20th century was the fifty-fold increase in the productivity of the manual worker in manufacturing. The most important contribution management needs to make in the 21st century is similarly to increase the productivity of knowledge work and the knowledge worker[(2)].” In other words, Drucker sees a fundamental difference in the nature of work in the 20th and 21st centuries.

The 20th century was one of dramatic improvement in the productivity of factory work. The driving force behind this was the scientific management theory of American engineer and management theorist Frederick Winslow Taylor. Taylor conducted rigorous studies of shoveling work at a steel mill. He broke the work down into separate processes that he then looked at individually to identify activities that were unnecessary or that could be done more quickly. Based on these studies the necessary processes were then standardized. This made it possible for work that had been believed to be possible only by experienced staff, to be done instead by inexperienced people while still maintaining a level of quality.

Taylor’s scientific management theory was adopted across a wide range of activities during the 20th century. This led to work associated with diverse tasks and services being broken down into processes and standardized to eliminate waste.

In the latter half of the 20th century, computers were introduced as a way to achieve this with even greater rigor. Once a computer program was written, it could be used to process and output large amounts of data. Initially used for accounting, computer applications have been expanded into all areas of corporate activity to monitor and automate such business processes as order entry, procurement, production, inventory, dispatch, and human resources. In accordance with Taylor's philosophy, business activities were broken down into individual processes and standardized, with computers being used to record and manage the status and progress of each standardized process. This achieved a fifty-fold increase in productivity and created the modern economies of developed nations.

Now, however, with services and other knowledge work accounting for more than 70% of all work in developed nations, Taylor's methods are no longer sufficient on their own. This is because of the extent to which changes have occurred in services and other knowledge work and the environment in which they are performed. Rigid and uniform practices are frequently unable to cope with people's preferences, greater individual diversity, and the characteristics of specific locations or regions, not to mention fluctuations in things like demand and prices. Rigid business processes based on the Taylor model are a poor match with reality, and even defining business processes is difficult. Similarly, the definition and measurement of business productivity are also frequently difficult.

## Benefits of Introducing Computers

In parallel, this also means there is a limit to the productivity benefits that can be achieved by introducing computers as described above. Conventional computers do not learn and grow when circumstances change. For this reason, they are referred to as hard-coded systems, because the programs have to be written explicitly.

In accordance with Taylor's philosophy, people who improve their capabilities by sharing best practices are called Human 2.0, which is to say they are characterized as standardized workers. By contrast, people whose capabilities have been specialized through the division of labor are called Human 1.0, which is to say they are characterized as specialized workers (see Fig. 1).

Current corporate information systems have been developed to support the work of this second generation (Human 2.0). Unfortunately, this approach is reaching its limits in terms of cost-benefit. This is the background to the emergence of the third generation of machines and information systems described in this article.

The productivity of nurses or department store sales staff, for example, cannot be improved using manuals alone. In addition to their core role of caring for patients, nurses also need to produce documents and to consult and coordinate with other people. Likewise, in addition to their core role of recommending products to customers and encouraging their interest, sales staff also need to produce documents, check inventory, and keep track of deliveries. In a diverse and ever-changing environment, it is not possible for manuals to document things like how to prioritize this work and allocate time, meaning that the nurses and sales staff must make these decisions for themselves.

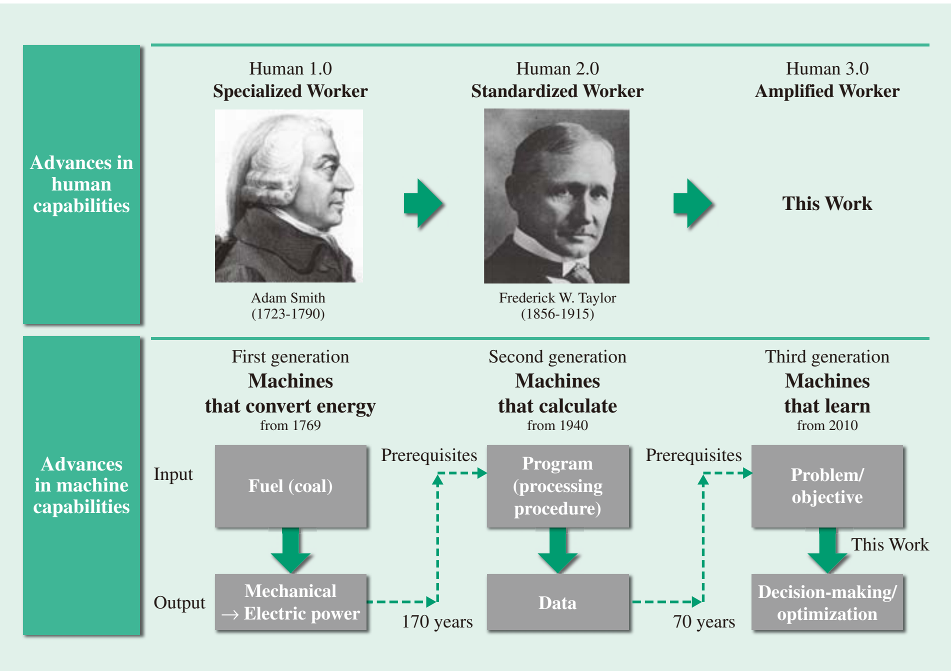


*Fig. 1—Improving Productivity through Advances in Human and Machine Capabilities.*
*People who have built tools and have been specialized through the division of labor (first generation) amplify their capabilities by disseminating and learning from the know-how of experts (second generation), and by autonomously learning from real-world situations that transcend time and space (third generation).*

What is important for services and other knowledge work is to set work objectives and other goals. In this article, these are referred to as outcomes. Given a clear objective, it is possible to make flexible and accurate decisions under widely varying circumstances. Past information systems have not been able to satisfy this need for flexibility. Instead, they have tended to result in more standardized practices.

### New Image of Humans

What changes all of this is the advent of new methods based on the use of AI. Modern information systems are steadily building up huge quantities of data. The changes taking place in businesses and other parts of society are reflected in this data. By utilizing the data, it is becoming possible for computers to modify the logic by which they operate in accordance with changing circumstances. In other words, AIs have the ability to learn from data and make decisions.

Further underpinning this progress are developments in data collection methods. Ongoing advances in technology include sensors, wearable devices, robots, and drones. Combined with AIs that can learn from this data autonomously, this can create systems (AI-based systems) capable of adapting flexibly to change.

These new AI-based systems have the potential to provide powerful augmentation and amplification of human learning abilities, and can be expected to deliver productivity improvements. This represents the third generation, Human 3.0. A feature of this generation is the amplification of human capabilities. In other words, an amplified worker (see Fig. 1). Whereas enterprise resource planning (ERP) and other similar computer systems were used for standardization in Human 2.0, AI-based systems that learn will assist people in the third generation, Human 3.0, with ongoing learning from quantities of data that are too large for humans to consider on their own. This will enable decision-making with an accuracy that would be impossible when relying only on human experience. It will also allow flexibility in decision-making in ways that are not able to be documented in conventional procedure manuals such that systems will be able to adapt if business conditions change (such as distribution channels or supply and demand conditions). This contrasts with the tendency for people to persist with practices that have worked in the past, even when circumstances change.

Accepted wisdom in the past has been that business process standardization and procedure documentation represent best practices for improving business efficiency, and customers and staff have adapted to work with predefined procedure manuals and machines. In practice, however, the policy of standardizing business processes and implementing them on a computer has not been a success in many services that need to deal with change and a wide range of other conditions. In fact, the concern has been that they pose an obstacle. This in turn has impeded the growth of the traditional information system business.

In the third generation of work, it is the computers and other machines that adapt to humans rather than humans adapting to machines and processes. They support people who make autonomous decisions amid changing circumstances and who are accountable for the results.

## AI AS A WAY TO SURVIVE AN UNPREDICTABLE FUTURE

The arrival of AI represents more than just the provision of a convenient tool. Rather, it changes how we go about solving problems and other aspects of our life. While the future is full of endless new possibilities, it also harbors threats to our existence.

In talking about the impossibility of predicting the future, Peter Drucker offered the following insight.

> We know only two things about the future:
> It cannot be known.
> It will be different from what exists now and from what we now expect.
> (...)
> The purpose of the work on making the future is not to decide what should be done tomorrow, but what should be done today to have a tomorrow.[(3)]

In other words, we are only able to act today. We have no direct means of changing the past or the future. We can only influence the future by how we act today.

However, the author believes there are two different ways of thinking about the present (the point where past and future meet).

The first is to see the present as resting on the knowledge and events of the past. Under this view, what is important is to study established knowledge (academic, scientific, and practical knowledge) and put it to use today. When confronted with things not covered by past knowledge, the only option is to deal with it as it presents itself.

The second is to view the present as the vanguard of an unpredictable future. In response, even if the future is impossible to predict, it should still be possible to establish ways of dealing systematically with a diverse range of changing circumstances. This view of the present is about striving to achieve this.

The 20th century was a time in which scientific discoveries were made in a wide range of fields, with widespread technological applications. Because knowledge was being created so rapidly that learning found it hard to keep up, it was a time in which the former approach to the present prevailed. It is an approach that is deeply engrained within people.

AI is a new way of doing things that represents a shift toward the latter approach to the present and also a turning point that combines both.

Which of the two approaches has been emphasized has changed over time. Historically, there have been times in the past when dealing systematically with a future that is impossible to predict was seen as more important than it is now.

The Edo Period was one such time. Kaishuu Katsu and Mutsu Munemitsu provide examples. Both of them changed history in the transition from the Tokugawa shogunate to the Meiji Era. They also had something else in common, the ship in which Kaishuu Katsu visited America was the Kanrin-maru. The main work of Mutsu Munemitsu was his *Kenkenroku* diplomatic memoirs. Each of these people chose the respective names from the hexagrams described in the oldest of oriental classics, the *I Ching*.

Written more than 2000 years ago, the *I Ching* states that there are ways of dealing systematically with the unknown based on the identification of the smallest of signs. The scope of the *I Ching*'s application extended from matters of state to personal decisions. The other English name given to the *I Ching* is *The Book of Changes*. It systematically classifies unknown changes into 64 hexagrams and explains how they are to be interpreted. Given its place as the foremost of the *Four Books and Five Classics* of Confucianism[(b)], the *I Ching* clearly placed ways of dealing with the unknown as central to learning. Over and above knowledge of practices and information that have already been established, it placed an emphasis on ways of dealing systematically with these unpredictable situations.

Specifically, *xian*, *lin*, and *jian*, the Chinese characters used in the above names, are three hexagrams from the full set of 64, something that was well known among learned people of that time.

The *xian* hexagram refers to conjoining with space and other aspects of the world in ways that go beyond words. The *I Ching* classifies changes using hexagrams that can be specified by a six-bit binary number, with changes being represented by a combination of two states, *yin* and *yang*. If a binary representation is adopted in which 0 is *yin* and 1 is *yang*, the code for *xian* is 001 110. The term *lin* (110 000) refers to acting forthrightly to unhesitatingly grasp opportunities that arise. Accordingly, *Kanrin* (the Japanese translation of *xian – lin*) can be interpreted as indicting a situation in which one should be conjoined with the world in ways that go beyond words, and by doing so, be ready to act forthrightly to seize opportunities that present themselves. In other words, by using the *I Ching*'s language of hexagrams to name his vessel, the name expressed the attitude of facing up to an era of new changes in the transition from the Edo to the Meiji Period.

Similarly, the *jian* hexagram (001 101) referenced by Mutsu means to progress one step at a time despite adversity by asking for help from others. The *Kenken* in the title of Mutsu's book is the Japanese translation of *jian-jian*, with the repetition serving to emphasize this meaning. That is, it means to progress one step at a time despite adversity by asking for help from others, such that even if this leads to more adversity one can continue to make steady progress by asking for help from others. In this way, a large number of changes (64×64 = 4,096) can be expressed by pairs of hexagrams.

For learned people of the Edo and Meiji periods, the pursuit of learning was all about becoming the sort of person who adopts the correct attitude to the unknown. The *I Ching* was the canonical and foremost text for this purpose.

Furthermore, this methodology of the *I Ching*, namely the use of data as a basis for selecting from a set of systematically predefined options, is the same as that used by modern AI. The author discusses this in more detail below.

It is completely different from the modern idea of learning as being an understanding gained from sources such as books or schools. The view that learning was about the acquisition of pre-existing information spread quickly, starting from around the generation that came after those educated during the Edo Period

(b) *Four Books and Five Classics* of Confucianism
Nine books that are recognized for their particular importance in the teachings of Confucianism. The four books are the *Analects*, the *Great Learning*, the *Doctrine of the Mean*, and the *Mencius*. The five classics are the *I Ching*, the *Book of Documents*, the *Classic of Poetry*, the *Book of Rites*, and the *Spring and Autumn Annals*. Confucianism is the general term for the ideas and beliefs attributed to Confucius.

TABLE 1. Five Requirements for Responding Systematically to Unpredictable Situations
*There is a need for broad applicability to unpredictable problems in which the situation cannot be foreseen.*

| | Problem | What to decide |
|---|---|---|
| F0: Outcomes | What is the objective to be achieved? | Outcomes (KPIs) |
| F1: Scope | What is the scope that needs to be considered? | Input data (scope) |
| F2: Options | What potential actions are available? | Options |
| F3: Decision criteria | What are the criteria for selecting which action to take? | Evaluation function |
| F4: Decision and optimization | Which action should be taken (decision) | Actions |
| | F1 to F4 are revised based on the outcomes of the action taken. | |

KPI: key performance indicator

described above and continuing to the era of catch-up and overtake in the Meiji and post-war periods.

Now, however, new AI methodologies are placing a fresh emphasis on responding systematically to unpredictable changes over and above the utilization of existing knowledge.

Furthermore, as the essence of management, as noted by Peter Drucker, lies in adopting the right approach to an unpredictable future, AI will transform corporate management.

## NEED FOR AI TO HAVE BROAD APPLICATIONS

In practice, how is it possible to respond systematically to unpredictable situations? And how can the capabilities of computers help with this?

First, there is a clear need to use general-purpose methods. Countermeasures built on guesswork will be of no use in unanticipated situations.

The practice adopted in the past has been categorization. The idea was that, by grouping situations into categories and devising countermeasures to each one in advance, the correct response could be delivered when something happened. While this works well for simple problems, it fails when the situation is complex. The accurate categorization of situations requires a large number of categories. Furthermore, because it is in principle impossible to anticipate all possible situations, there is an ongoing need to update the categories and countermeasures. In many cases, this takes too much work to be practical.

By contrast, rather than relying on predefined categories, the new approach using AI involves loading large amounts of data from past and present and taking advantage of the overwhelming data processing capabilities of computers to infer the appropriate response from past examples.

These new techniques require broad applicability (i.e. they need to be general-purpose) in order to be able to deal with unpredictable situations. Put another way, the progress of AI depends on the extent to which it is capable of broad application.

## PROGRESSIVE DEVELOPMENT OF AI

Along with the following five requirements associated with responding to unanticipated changes, how broadly AI can be applied depends on the extent to which these can be generalized.

The five requirements for responding systematically to unanticipated situations are as follows (see Table 1).

F0: Outcomes: Determining the objective to be achieved
F1: Scope: Determining the scope that needs to be considered
F2: Options: Devising a list of options (potential actions)
F3: Decision criteria: Devising an evaluation function that specifies the criteria for selecting which action to take
F4: Decision and optimization: Using the evaluation function as a basis for selecting which option (action) to take

F1, F2, F3, and F4 are then revised based on the outcomes of the action taken.

There is no great difficulty in developing a program for a particular problem that satisfies these five requirements. What is difficult is achieving the broad applicability needed to use the program on unpredictable problems in which the circumstances are not known in advance.

While achieving broad applicability is more difficult the higher the requirement is in the table

Table 2. AI Levels
*AI is classified into levels 1 to 4 based on its scope of application. Level 0 applies to existing mechanistic systems that are not AI.*

| Level | Category | | Features (outcomes are given) | Examples* |
|---|---|---|---|---|
| 4 | General-purpose AI | Scope | Decide by learning from data to determine scope and options | Corporate strategy, urban design, wellbeing policies |
| 3 | | Options | Decide by learning from data in a given scope to determine options | Generation of programs for inventing drugs or materials |
| 2 | | Judgment | Decide by learning from data for a given scope and options | Optimization of factories, warehouses, or sales |
| 1 | Special-purpose AI | | Update specified parameters based on learning from data | Recommendations, answering questions |
| 0 | Non-AI | | Fixed logic specified by hand | Existing business systems |

AI: artificial intelligence
* Examples for levels 3 and 4 are the author's predictions

(F1), once achieved, the higher the requirement is in the table, the greater the possibility is of applying the AI program in a wider range of situations.

An outcome is an indicator of success (how good or bad a result is). In business these are also called key performance indicators (KPIs). Choosing these indicators is an important human decision. It is something that in principle must be decided by people.

There has been considerable discussion and research into artificial general intelligence (AGI) in recent times. While the definition of AGI remains unclear, it is frequently used to refer to artificial intelligence that has a similar broad scope to human intelligence. The idea that the achievement of AGI will bring about a singularity has been widely debated[(4) – (7)]. In the sense used above, the pursuit of broad applicability in itself is the right way forward for AI. However, the author's personal view is that arbitrary distinctions about whether or not AGI has been achieved are undesirable.

In other words, people should avoid making arbitrary distinctions and aim instead to progressively expand the applicability of AI. The five requirements above are useful for this. The author has devised his own classification for the progress of AI comprising four levels based on its scope of application (see Table 2).

Level 0 indicates traditional mechanistic systems that do not include learning from data. These are not AI. Level 0 programs are implemented as fixed logic and are written by hand. Most existing corporate information systems and infrastructure systems are at level 0.

Level 1 indicates systems that autonomously modify parameters based on data to achieve an objective, and in which these parameters have been specified by people. Most systems that use machine learning[(c)] are at level 1. The simplest example of this is multiple regression[(d)], a technique for determining the parameters of an approximate model (gradient and intercept) by fitting it to actual data (scatter diagram) using the least squares method. Other forms of machine learning include more complex forms of multiple regression, such as support vector machines (SVMs), decision trees[(e)], deep learning[(8)], and collaborative filtering[(f)]. In essence, however, these are just more complex models that achieve greater accuracy by increasing the number of multiple regression parameters. These machine learning algorithms are already well known and are available through open source libraries such as the R language.

These level 1 systems are special-purpose AIs that are necessarily designed for a particular purpose only. Well-known examples include the generation of customer recommendations in the retail sector and systems for performing facial recognition from photographs. A system for generating quiz answers[(9)] and a technique for identifying a person's face in web

(c) Machine Learning
An AI technique that performs recursive learning from past data and uses this to identify meaningful patterns. Predictions of the future can be made by applying the results to new data.

(d) Multiple regression
An analysis technique for predicting a particular variable (objective variable) using multiple variables (explanatory variables). In the case where the value of purchases by a customer at a store is the objective variable and the customer's annual income, age, gender, and family structure are the explanatory variables, to use annual income alone to predict the value of purchases would be single regression analysis, whereas using the customer's annual income, age, gender, and family structure to make the prediction is multiple regression analysis.

(e) Decision tree
A technique for assisting with decision making by using a model with a tree structure to analyze the factors involved in achieving an objective. In the machine learning field, decision trees are used as predictive models in which the objective variable and explanatory variables are represented by a tree structure. The technique is commonly used in data mining.

(f) Collaborative filtering
A method for inferring the preferences of a particular user from their history of activity that hypothesizes that user preferences will be similar to those with a similar past history of activity and creates a database of the relationships between the history of activity and preferences of a large number of users.

images[10] have been reported in the media, and both of these are special-purpose level 1 AIs.

In the case of level 1 systems, however, the choice of data (feature values) to input to the algorithm is determined based on hypotheses made by humans, requiring the development of a program, and problem-specific program development is also required in association with the algorithm. Accordingly, each problem to which the system is applied involves accompanying analysis and development costs. Furthermore, because the systems lack general-purpose capabilities (are unable to go beyond hypotheses that involve feature values anticipated by people), they are unlikely to produce results that go beyond human ideas.

By contrast, level 2 AIs have the broad applicability to overcome these limitations. Level 2 systems generate decision criteria automatically from large amounts of data and select the best option from among those offered by people. In this case, the scope (range of data to be considered) and outcomes are given by people (see Fig. 2).

A major difference from level 1 is that both the form of the evaluation function used for decision making and its parameters are determined automatically from the data. This means that, in level 2 systems, people do not need to predefine the hypotheses about the subject matter, and therefore they can generate solutions that people had never considered.

Another difference is that there is clear independence between level 2 AI and non-AI systems (IT and other equipment) (see Fig. 2).

It is the broader applicability of level 2 AIs that makes this independence possible. This leads to significant savings on the cost of implementation. Because level 1 learning algorithms are permanently embedded in the system, there is no clear distinction about where the AI starts and ends. Accordingly, there is a large cost associated with program development and maintenance for each problem, and only in rare instances do the benefits (outcomes) outweigh the costs.

The Hitachi AI Technology/H (hereafter referred to as H) announced by Hitachi in 2015 is a general-purpose level-2 AI. As far as the author is aware, it is the first such level-2 AI to enter practical use. H automatically generates more than a million hypotheses, identifies which factors are important, and determines in a quantitative manner the conditions under which better outcomes will be achieved. This technique is called leap learning. A general-purpose AI can be added on to an existing system to transform it into a system that learns and grows by specifying the outcomes and the inputs and outputs.

The daily operation of a warehouse was improved by connecting a general-purpose AI to its warehouse management system (WMS). The outcome in this case was the minimization of total working time. To achieve this, H received the latest data from the WMS each night and used it to determine an equation (evaluation function) expressing how to minimize the total working time. When the dispatch orders (numbering in the thousands) were ready in the morning, H then performed automatic scheduling to prioritize which orders to execute first and output the results as a picking list. While the warehouse staff would then perform the work in accordance with these instructions, in practice they would make various trial and error initiatives during their work. The consequence of this was that work time would decrease on some days and increase on others. As this in turn became input data for the AI, the schedule produced for the next day would take it into account. In this way, integrating a general-purpose AI into an existing system succeeded in creating a learning arrangement whereby the AI and staff cooperated on a daily basis. The warehouse achieved an 8% improvement in productivity.

Other projects achieved a 15% increase in sales at a retail store and a 27% increase in orders at a call center. As described in this issue of *Hitachi Review*, the technology is being deployed in applications such as finance, railways, factories, and water treatment plants, with a total of 24 projects having commenced, covering seven different industries (see Fig. 3).

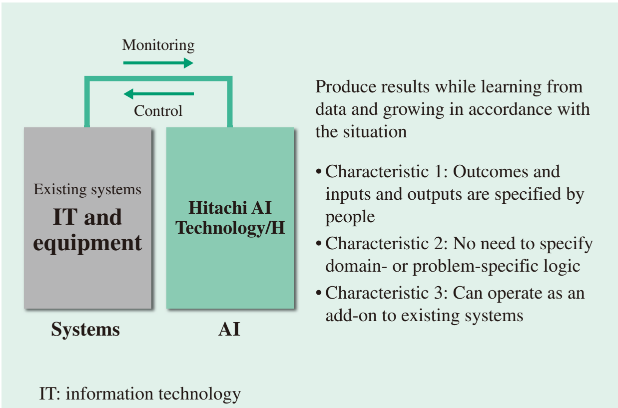


*Fig. 2—Features of General-purpose AI (Level 2 and Higher).*
*People specify the outcomes and the inputs and outputs (based on factors such as the problem scope) and the AI operates based on the data to find or control the conditions that improve the outcomes. There is no need to specify problem-specific logic. In general-purpose AI, the AI and non-AI systems are separate.*

| Retail | Logistics | Seawater desalination plant | Call center |
|---|---|---|---|
| Identify optimal uses of staff time | Identify optimal conditions for work and supervision | Identify efficient operating practices | Identify how to improve productivity by talking to staff |
| 15% increase in sales per customer | 8% improvement in productivity | Estimated 3.6% reduction in operating costs | 27% improvement in order rate |

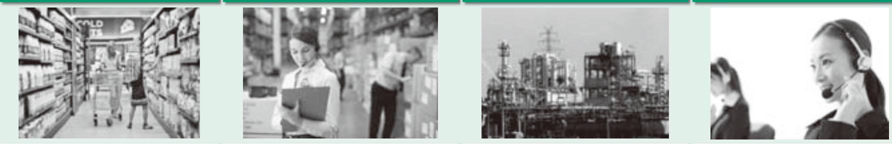

*Fig. 3—Applications of H General-purpose AI.*
*H has been used in 24 projects across seven industries, including finance, retail, logistics, plant, transportation, and manufacturing, where it has generated actions and improvements in a general-purpose manner using the same AI software.*

The important point is that the same general-purpose AI software (H) is being used without its being customized for the specific industry or problem. This has resulted in a sudden expansion in the scope of application of AI.

While the system is a level-2 AI with a wider range of application, it is still only capable of choosing the best alternative from a range of options provided by people. In practice, this is enough to implement fairly complex control functions. In the warehouse, for example, the AI prioritizes which of the thousands of dispatch orders to perform first. The total number of combinations for executing 1,000 dispatch orders is nearly infinite (approximately 1,000 factorial). This can be determined accurately.

However, producing more creative answers requires the even greater degree of generality provided by a level 3 AI. For level 3, the AI uses data to determine the options for what action to perform next. An AI with this capability would, for example, be able to produce new drugs or other materials or write software automatically based only on examples. What makes this intrinsically more difficult than level 2 is the need to determine the procedures or sequences for generating these. Here, the term "procedure" means a complex combination of things like conditional branches and loops based on intermediate results, elements that are not present in level 2. The inclusion of these causes a dramatic increase in the size of the search space, making it difficult to learn from example data.

Up to level 3 it is people who determine the scope and decide which data to input. In level 4, the AI also determines what data to input (the scope). With this capability, the ability of AIs to choose their own inputs enables a higher degree of generality to be to achieved by combining AIs in complex ways.

If level 4 AIs can be achieved, it should be possible to devise sustainable national and corporate growth strategies even amid unpredictable changes in circumstances resulting from globalization, and to generate the actions needed to guide people toward their own wellbeing.

## IMPACT OF GENERAL-PURPOSE AI

For the purposes of this article, AIs at level 2 or higher are referred to as general-purpose AIs and those at level 1 as special-purpose AIs. Level 2 AIs can already be used on a wider range of problems than could be covered by any individual person. The quantity of data that can be loaded and knowledge that can be extracted from it is much greater than can be processed by one person. However, as noted above, this should be thought of not as machines outstripping humans, but as a measure of how far human capabilities have been enhanced.

To demonstrate the power of these general-purpose AIs, Hitachi used LEGO*1 blocks to build a robot capable of swinging on a playground-style swing and connected it to the H general-purpose AI. The outcome (objective) was specified as maximizing the amplitude of the swing. The system was set up so that movement data was input into the AI via the controller and so that the AI could control the movement of the robot's knees. The robot was successfully able to use the swing after only about five minutes of system operation, without the use of any predefined knowledge.

In this way, an existing system was transformed into one capable of learning, applying what it has learned, and growing simply by integrating it with a general-purpose AI and providing the desired outcome and data with the potential to influence that outcome.

Such systems based on general-purpose AI can operate 24 hours a day, 365 days a year. Nevertheless,

*1: LEGO is a trademark of the LEGO Group.

they are able to learn quickly. It was astonishing that it took only five minutes to learn how to use a swing. This also demonstrates its ability to adapt to changes in supply and demand, prices, people, places, or time. Unlike people, it can continue doggedly to adapt without requiring instructions. Moreover, the H general-purpose AI also indicates the reasons for its decisions.

Past special-purpose (level 1) AIs required new programs to be written for each problem. The provision of product recommendations at a retail store, for example, required dedicated software to be developed. With a general-purpose AI, by contrast, product recommendations and optimal product ordering or product ranges can be achieved simply by changing the configuration of the H software, without new program development.

The emergence of general-purpose AI is expected to have as great an impact as the initial development of computers some 80 years ago.

The current interest in AI began about two years ago. Nevertheless, behind the scenes, AIs have been playing a part in people's lives for the last 15 years or so. When someone does a web search in response to a product recommendation from an e-commerce site they are using AI technology without their knowing it. This is because AI technology is used behind the scenes in both cases. However, these are both special-purpose AIs designed specifically for the application. The recommendation engine cannot be used for web searches and vice versa.

Meanwhile, this general-purpose technology[11] (the term used by US economist Erik Brynjolfsson) will come to be more broadly applied after initially proving itself in specialist applications. This is a very important turning point because this broader applicability will greatly expand potential applications while also driving down costs.

Mobile phones provide an example of this. The first mobile phones were vehicle-mounted and enabled people to call each other whenever they wanted. Subsequently, the widespread adoption of smartphones transformed the mobile phone into a truly general-purpose device, thereby greatly increasing its value. The size of the resulting market was much larger than it had been prior to this wider scope of use.

Likewise, given that an evolution from special-purpose to general-purpose AI can be anticipated, Hitachi chose to start development of general-purpose AI earlier than the rest of the world. This work is now beginning to bear fruit (see Fig. 4).

## AI MEANS SEARCHING A LARGE INFORMATION SPACE

### Essence of AI Technology

What is the nature of the technology that makes this AI possible? The answer has already been given in *Computing Machinery and Intelligence*[12], published in 1950 by Alan Turing, the mathematician who provided the theoretical underpinnings for computers. Turing

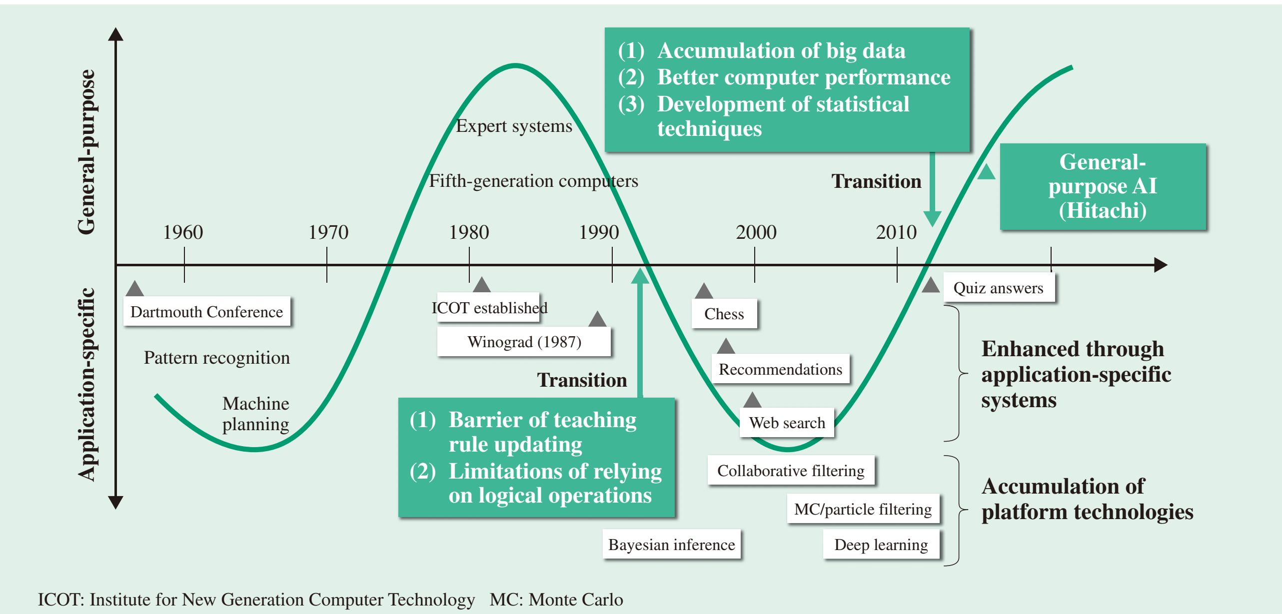


*Fig. 4—Transition for Special-purpose to General-purpose AI.*
*AI techniques developed for specific applications are being redeployed for general application.*

proposed that the objectives of learning machines can only be achieved by trial and error. It is through this trial and error that computers derive their intelligence. The following explains in more detail.

All AIs, regardless of their level, build models for improving outcomes from large amounts of actual data. What this actually involves is finding, by trial and error, the conditions in this large information space under which the outcome is maximized.

While this may not seem like much, the availability of large amounts of data and improvements in the speed of computers mean that, in practice, the difficulties of AI have become concentrated around the problem of how to search an information space.

However, the larger the search space, the more the search process comes to resemble prospecting for gold. The higher the AI level (as defined above), the greater the dimensionality and the more difficult the search. Accordingly, the key to AI lies in how to search such a large space of unknowns both efficiently and systematically.

Traditionally there have been two ways to go about such a gold prospecting search. The first is to perform a random search. This is equivalent to saying that, when dealing with the unknown, you may as well search blindly.

The other method is to search in the vicinity of places where previous searches have found good results (have obtained a high value for the outcome). This is based on the assumption of continuity in the information space, such that there must be a reason why good results are obtained in a particular location, and therefore it can be anticipated that a "seam of gold" must be present somewhere near places that have delivered good results in the past.

While algorithms based on this principle go under a wide variety of names that are prone to confuse non-specialists, they are fundamentally quite simple. They consist of the Monte Carlo method[g] (which is based on random numbers) and its derivatives, with techniques used in AI including the Markov-Chain Monte Carlo (MCMC) method, Hamiltonian Monte Carlo method, particle filtering, Boltzmann machines, simulated annealing, genetic algorithms, and quantum annealing. Deep learning neural networks, a topical subject in recent times, use these techniques internally.

(g) Monte Carlo method
A calculation technique for obtaining an approximate solution by repeating a simulation many times using random numbers (random digits like those obtained by throwing dice).

## Learning from the Universe and Evolution

It is anticipated, however, that searching large information spaces, as required in level 3 and level 4 AIs, will need more than the two simplistic methods described above.

In fact, ways of achieving this are already becoming apparent. These methods derive from the idea that information spaces are not uniform. In other words, space is not an empty vessel and the outcomes being sought are in fact very unevenly distributed. This means there is no need to perform evenly spread random searches of large areas.

The reason this statement can be made is due to a deep physical principle, namely that information is something that derives from the universe, and that the universe itself is a form of information[(13) – (15)]. Approximately 14 billion years ago, immediately after the Big Bang, the universe contained only hydrogen and helium. Describing this state required much less information than would be needed to describe the present-day universe. In other words, the information content of the universe at that time was smaller. This was followed by numerous generations of stars forming during which planets were also created in orbit around these stars, including our own beautiful Earth. On Earth, many different types of complex life arose over a period of about four billion years, leading ultimately to human beings. Humans in turn invented writing, media, and other tools, subsequently giving rise to systems, organizations, and psychology. The space that encompasses all of these outcomes represents a huge information space. The universe itself contains all of the information that represents these things.

The principles that underpin the creation and progression of this space are already known. In physics, they are referred to as the first and second laws of thermodynamics, namely the conservation of energy and the rule that entropy always increases. While these laws were initially used to explain thermal processes such as engines and turbines, they also govern the creation and progression of all things.

A simple way of putting it is to say that, while resources are constant, neither increasing nor decreasing, information is continually increasing through new combinations of resources and therefore the universe has come to contain a greater diversity of information. This combines the law of conservation of resources with that of increasing diversity of information.

The important factor in this is that conservation of resources and diversity of information are not independent of each other, rather, they make up two halves of the same law. The principle by which the universe is created and expands is that of a continual increase in entropy (diversity of information) under the constraint of a conservation of energy (resources). The diversity of information serves as the universe's objective function and the limitation on resources serves as the constraint.

Even with finite resources, information can increase indefinitely through combination. Here, it is helpful to recall the formulas taught at school about permutations and combinations. Use of factorials can quickly result in extremely large numbers. This means that the number of potential resource combinations is nearly infinite.

This indicates the desire expressed above relating to searching large spaces. If information becomes increasingly diverse without constraints, it is necessary to search this large space uniformly. In this case, performing needle-in-a-haystack searches becomes increasingly difficult as the number of dimensions of the space increases. If, on the other hand, information becomes increasingly diverse under the constraint of finite resources, it can be shown that the desired outcomes will be very unevenly distributed[16]. This means there is the potential to significantly narrow down the space to be searched.

The H general-purpose level 2 AI already makes use of this principle in some of its operations. It is anticipated that achieving levels 3 and 4 will require more systematic use of the principle.

As to whether it is really possible to build level 3 or level 4 AIs, there is no doubt about this because their existence has already been proven by the evolution of life.

Evolution was frequently assumed in the past to be a random search in the form of natural selection, with survival as the objective. However, the mathematician Gregory Chaitin has asserted the need for a new principle, stating that the complexity of modern lifeforms could not have been achieved in four billion years by a random search[17]. Rather, it seems likely that evolution is already putting the above principle to good use.

Discussion of AI often calls on comparisons with the brain, however, the secret key to effectively navigating large information spaces can be found in the mechanism of evolution, which gave rise to even the brain among other things. This could provide a mathematical principle for explaining how the universe has come to be the way it is. We still need to learn from nature.

## RELATIONSHIP BETWEEN PEOPLE AND AI

### Does Technology Make People Happy?

In recent times, the subject of the relationship between AI and people has arisen frequently in books and other media.

There is no doubt that technology has made people's lives easier up to now. However, the question of whether technology makes people happy is not such an easy one to answer.

Whether AI will make people happy is becoming an important question.

Speaking personally, even since the author was a university student, he has had a strong interest in the questions of what constitutes happiness and what can be done to bring it about. Back then, he was particularly fond of the book, *Happiness: Essays on the Meaning of Life* by the Swiss philosopher Carl Hilty[18]. After starting at Hitachi, however, his focus shifted to things like technology and money, and it did not occur to him to consider happiness in his work.

As explained earlier, the author had to start all over again 20 years after joining Hitachi when he and his colleagues had their careers reset. Having had their escape routes cut off, their thoughts about what future direction they should now take related to the importance of data. That is, they discussed the idea that data, including data about people, would be more important in the future. The author believes that, somewhere in the background of all this, he was influenced by his interest in people's happiness during his time as a student.

As a result, a decision was made to develop devices for measuring large amounts of data about people, leading to the development in early 2006 of prototype wearable sensors in the form of wristbands and nametags, the latter being worn on the chest. Confident of the small size and low power consumption of the devices, they could be used to collect a steady stream of data on people powered only by a small battery.

Accelerometers were of particular interest[19], [20]. A wearable sensor with a built-in accelerometer can collect data on bodily movements 24 hours a day. The idea was that it would be possible to determine a variety of information about people's behavior from their movements (see Fig. 5).

In the author's role as the leader of this project, he was its first experimental subject. Since March 16, 2006, the wristband wearable sensor has remained on his left wrist throughout the 10 years that have passed. This means that all of the movements of his

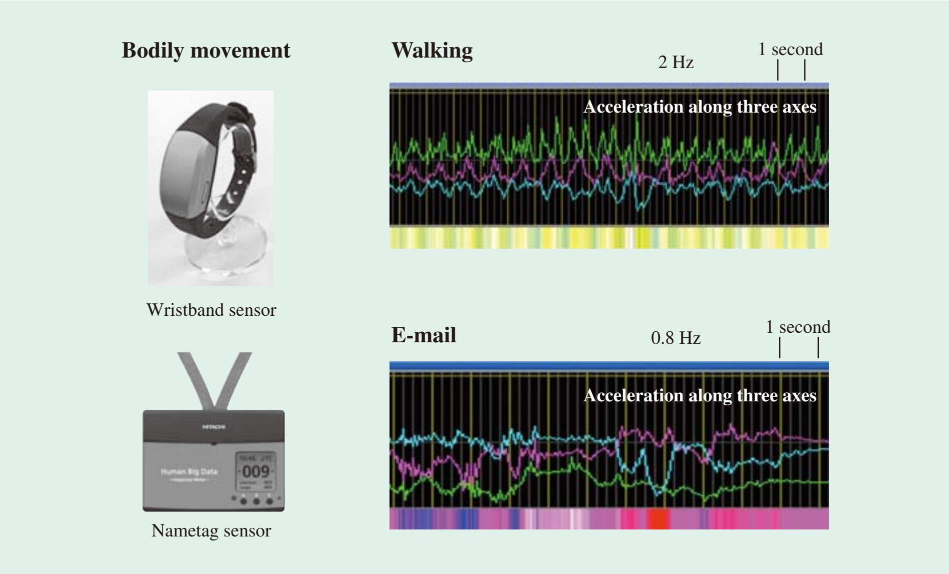


*Fig. 5—Wearable Wristband and Nametag Sensors and Acceleration Waveforms (x, y, and z Axes).*
*Walking gives a waveform with a frequency of approximately 2 Hz and writing an e-mail gives an intermittent waveform with an average frequency of about 0.8 Hz.*

left wrist over the last 10 years have been recorded on a computer(16).

The visualization technique adopted to present this data is a graph called a life tapestry. Fig. 6 shows a trace of the data over the last seven years. Sleeping and waking, commuting, lunch breaks, and everything else from going on overseas business trips to working in the office is reflected in the data on wrist movements and is visible at a glance.

The data was collected and presented for a large number of users and an analysis was performed of the correlations with the results of questionnaires about personal activities. The results contained an interesting discovery. Individual data values only represent wrist movements, and this data on its own is of no value. However, it was also found that more meaningful conclusions could be drawn when the data was consolidated and patterns were observed.

Something occurred to the author as he looked at and analyzed the data on a daily basis: could it be that the data contains patterns indicative of the person's happiness?

Subsequently, more than a million days' worth of data was collected on people with millisecond resolution. The data covered a wide range of work in different industries. An analysis of the data, which

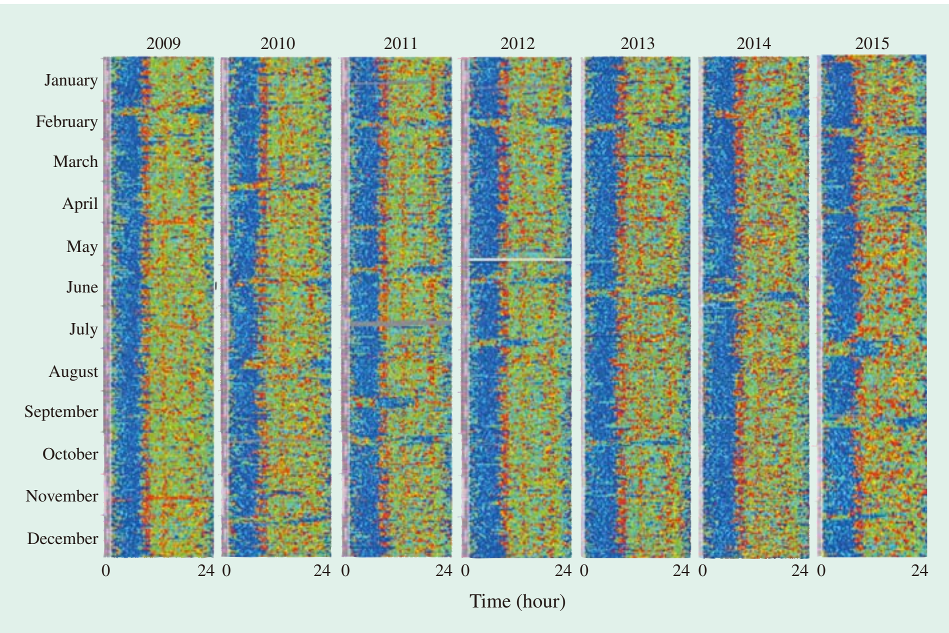


*Fig. 6—Bodily Movement of Author over Past Seven Years (at 50-ms Intervals).*
*The data is called a life tapestry. Red indicates active movement, blue indicates being stationary, and intermediate colors indicate intermediate states. Things like shifts in time zones due to overseas travel and variations in sleeping time can be seen at a glance. The reason for the increase in the variegated pattern of red during 2015 was due to a rapid increase in the number of lectures and other presentations on AI given by the author.*

included the use of an AI, succeeded in identifying patterns of people's happiness[21], [22]. This result was announced to the press in February 2015, and the author wrote an article that appeared in the Japanese edition of the *Harvard Business Review*.

## Measuring Happiness

How is it possible to measure happiness? Hitachi conducted a 20-question survey of 468 people across 10 organizations. How many days were you happy this week? How many days were you feeling good, lonely, or sad? The subjects were asked to respond to these questions on happiness with a ranking between zero and three. When the results were collated for each organization, it provided a quantitative measure of whether the organization was happy on average. Organizations with a high level of wellbeing and activity scored highly and those with low levels scored poorly.

The bodily movement patterns of the subjects were also measured by wearable nametag sensors worn on the chest. The results showed a very strong correlation between particular figures on bodily movement patterns and the results of the above happiness survey (see Fig. 7). The high correlation coefficient of 0.94 indicates that the happiness of an organization can be measured using wearable sensors alone, without performing a survey or similar study.

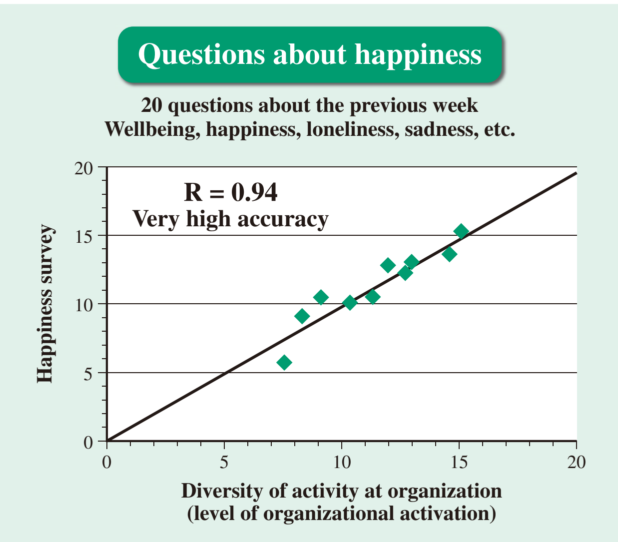


*Fig. 7—Identification of Bodily Movement Patterns that Correlate with Group Happiness.*
*The diversity of activity at an organization is strongly correlated with the results of surveys (questionnaires) of happiness at the organization (with a correlation coefficient of 0.94). The total sample size was 5 billion data points, with 5,000 person-days of data collected from 468 people across 10 organizations (statistically significant at less than 1%).*

The bodily movement patterns referred to here quantify the diversity of movement in a group. First, bodily movements were classified based on whether or not they were static. This totally unconscious pattern was then used to represent people's movements as a pattern of 1s and 0s, as in a bar code. There were cases where people appeared to have moved but stopped again within one minute, and cases when they continued to move for 20 minutes or more. The results indicated that, in practice, once people start moving, they often continue moving for about 10 minutes on average.

When this pattern of movement continuity was looked at for active organizations with a high level of happiness, what was found was a mix that included movement of both short and long duration. This was interpreted as a projection onto the time axis of a wide range of actions taking place at the organization.

In organizations with a low level of happiness and activity, on the other hand, this diversity of movement was low. In an extreme case, this might involve frequent instances in which people continued to move en masse for 10 minutes or so once they started moving, and then stopped again. There were no drivers to sustain the movement.

The term organizational activation was used to indicate this numeric representation of diversity in the duration of sustained movement. It represents bodily movement, which has a strong correlation with the happiness of the organization.

By using this technique, it is possible to measure organizational happiness as if it were weight or height.

## Rules of Happiness in Organizations

Once it became possible to measure happiness, something believed in the past to be impossible to measure, a series of previously unnoticed regularities were identified in organizations and work. These were collated in the form of three rules about happiness and are described below using the example of a call center.

The first rule is that organizations with a high level of happiness also have a high level of productivity. Many people will associate terms like happiness or wellbeing with the suspicion that the staff are taking things easy. The data clearly refutes this.

It was found at an outbound call center that, compared to below-average days, order rates were 34% higher on days with a high level of organizational activation, meaning a high level of happiness in the organization (see Fig. 8). Likewise, sales at a retail store were 15% higher on days with a high level of organizational activation. Similar results were

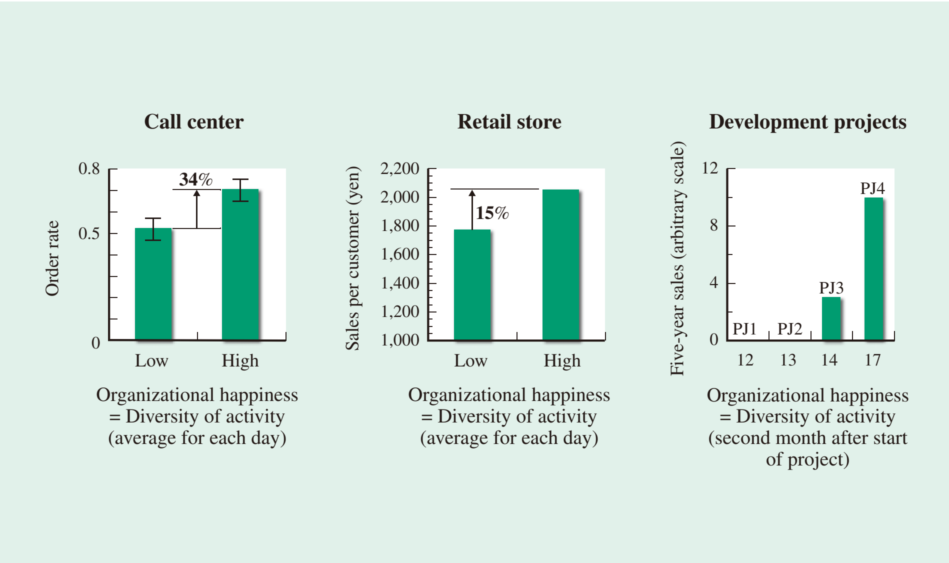


*Fig. 8—Relationship (Level of Organizational Activation) between Happiness and Productivity.*
*Examples are shown for a call center, retail store, and projects. The call center and store both achieved good results on days with a high level of movement diversity (level of organizational activation). The level of organizational activation in four development projects in the second month after starting was correlated with the contribution to sales of the development outcomes (statistically significant at less than 5%).*

obtained from development projects. Measurements were taken in four projects and it was found that the subsequent sales contribution from the deliverables developed was higher in those projects with a high level of organizational activation in the second month after the project started. Projects with a high level of happiness delivered better financial results. Put another way, bodily movement predicted the success or otherwise of a project long before the financial results became apparent. Using this knowledge, action can be taken on a project earlier than is currently the case.

The second rule is that both happiness and financial performance are group phenomena. There is a tendency to think of happiness as something that exists in the minds of individuals. The data clearly refutes this.

The following words were spoken by Kimiyasu Kudo of the Fukuoka Softbank Hawks professional baseball team after a victory.

> When we are losing and I ask the team what's happened to their voices, people like Kawashima and Fukuda (motivators) yell for us to go for it. When everyone shouts it together we really do go for it. Creating the right sort of atmosphere on the bench is also important.
> (Sports Nippon, September 18, 2015)
> (Author's translation)

This quote is saying that the atmosphere on the bench is very important for winning, to which the bench players Kawashima and Fukuda made a major contribution. While this may look at first glance like a belated expression of gratitude to the bench players after a win, I believe it was just as Kimiyasu Kudo said. This is because the exact same situation occurred at the call center and it was possible to capture quantitative figures on this in big data.

At the outbound call center, staff members call potential customers to sell them products. Performance is measured by the product order rate. A look at the data on order rates over the previous half-year shows that the staff includes both people with high performance (like the fourth batter in a baseball team) and others who do not perform as well. The make up of the staff varies from day to day, with a large number of high-performing staff members on some days and a low number on others. Naturally, it can be predicted that the overall order rate for the center will be high on days with a large number of high-performing staff members. In practice, however, no such correlation was found.

Bringing together a large number of high performers such as number-four batters does not create a strong team. A degree of group effect is present even in an individual activity like making calls and taking orders as instructed by a manual. The effect is likely to be greater still in work that requires team players.

Together with this, performance was 34% higher on days when there were a large number of people with a high level of diversity in their bodily movements and people who increase the diversity of bodily movements of those around them. It seems likely that these are people who improve the workplace mood. At a workplace where great effort is made to improve the order rate by even 1%, a 34% improvement is very large indeed.

What is interesting when looking at the performance of those people who contribute to the mood of the workplace is that there is no correlation with order rate.

These people improve the results of those around them by creating a better atmosphere around them. Don't all workplaces have people like Kawashima and Fukuda? But it is likely that people like this are not necessarily recognized by existing human resource practices.

The data also clearly shows that communication has a large influence on generating such a workplace mood. It was found that both happiness and order rates at the call center were high on days when there was vibrant conversation during work breaks. It was also found that both happiness and order rates were strongly influenced by who the supervisor spoke to on that day(23).

The third rule is that happiness is represented by a single measure regardless of the work or people involved. Many people will imagine that the definition of happiness will itself vary depending on things like the company, type of work, and region. However, the high 0.94 correlation coefficient does not allow for this interpretation. It means that a single measure can be used to represent happiness.

It follows that AIs can be used to improve happiness, and thereby to also improve productivity.

Specifically, Hitachi has developed a system that inputs staff activity data captured by wearable sensors into the H general-purpose AI and provides feedback on the communications and uses of time needed to improve the happiness of those individuals and those around them(24) (see Fig. 9). This has enabled the AI to understand people's happiness.

*Fig. 9—Photo of the Happiness Improvement Support Service Utilizing Wearable Sensors and AI.*
*By having staff wear wearable nametag sensors, the service is able to provide feedback on the communications and uses of time that will enhance the level of organizational activation (which is correlated with productivity and happiness).*
*Feedback provided using AI is customized automatically to the circumstances in the user organization.*

For example, happiness dashboard software was developed for the call center that outputs instructions to the supervisor as to who they should focus on talking to on that day(25). The software was used for more than one year and improved the order rate by 27%.

## Happiness is Infectious

This work has been publicized since the spring of 2015 and has generated a considerable response, including the publication of news releases describing work at a bank and an airline(26), (27).

Of course concepts like happiness and wellbeing are not things that were invented or proposed by the author. In fact, there has also been growing interest in happiness in academia over the last 15 or so years. It has been reported that people with a high level of happiness are more likely to enjoy good health, a long life, and successful marriage, with better income and career performance, 37% higher sales productivity, and 300% higher creativity, and that companies with a large number of happy people have 18% higher earnings per share than companies with few such people. Papers like this are appearing on a monthly basis(28).

However, happiness in the past has been measured by questionnaires, and given the inability to take realtime measurements, there has been little clarity as to what actions serve to improve happiness. Along with the divide between academia and practical business, this has led to little use being made of these findings in business. This situation has been transformed by the use of wearable sensors for measurement and feedback using general-purpose AI. The prerequisites for utilizing this knowledge in business are at last in place.

In practice, small things can influence happiness. Hitachi conducted experiments jointly with Professor Sonja Lyubomirsky and Dr. Joseph Chancellor of the University of California, Riverside(29). A group was divided randomly and the experimental subjects were asked to write down three good things that had happened to them during the past week. Similarly, the control subjects were asked to write down three things that had happened to them during the past week. The only difference was the inclusion of the word "good." This was repeated for five weeks and the results were reviewed for differences two months later. Clear differences were evident in the results. The experimental subjects had higher happiness, a greater sense of belonging to their organization, and a higher level of bodily activity from the morning.

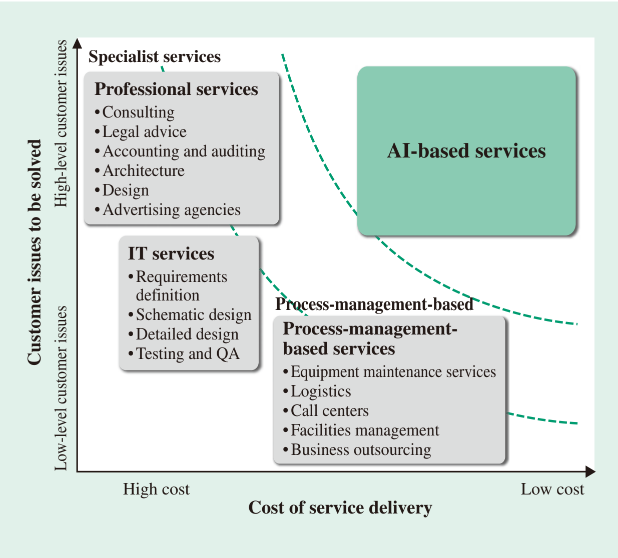


*Fig. 10—Tradeoff Between Customer Value and Cost in Services.*
*The use of AI enables high-level issues that derive from customer outcomes to be supplied at low cost.*

We were surprised that this action, which took only about five minutes each week to perform, could produce such a difference. It demonstrated how the subjective phenomenon of happiness could be altered significantly by small changes. There is still room for improvement in people.

## HOW AI WILL CHANGE SERVICES

AI has the disruptive power to change services.

In advanced economies such as Japan, the heart of the economy is shifting from manufacturing to services. Whether its previously strong manufacturers can become service-oriented is a major issue for Japan.

There are common challenges faced by anyone seeking to improve profits from services. The value of services is enhanced by solving the problems of customers. However, individual customers have different issues. Value is enhanced when solutions can be offered that are tailored to these individual issues. On the other hand, there is a cost associated with trying to supply individually tailored solutions. There is a tradeoff between these costs and the value delivered to customers, a situation in which profits are difficult to achieve.

Accordingly, many service industries have low profitability on average. Industry-average profit margins in areas such as distribution, retail, advertising, hospitality, and accommodation are below 5%.

In the past, services have adopted two approaches to this problem (see Fig. 10). One approach is professional services, which include a wide range of services such as consulting, law, and accounting. These services are provided in the form of work, making them labor-intensive. While some individuals may be capable of high performance, the larger the organization, the less variation there tends to be between companies on average. To achieve profits, such services often use star players to front their business but have the actual work done by young staff on lower wages.

The other approach involves process-management-based services. These are services in which processes can be standardized, such as distribution warehouses, call centers, and equipment maintenance. Costs are cut and profits achieved by using manuals and training. Services such as IT lie midway between these two approaches.

AI overcomes this tradeoff between individual optimization and cost to enable scalable services. Advertising services that are linked to Google*2 or other searches already earn margins that are an order of magnitude greater than traditional advertising services. These search-linked advertising services use a particular type of special-purpose AI to deliver advertising services that are customized to specific customers. Moreover, they improve customer value without incurring costs thanks to fully automatic customization. This enables businesses that transcend the above tradeoff.

It is anticipated that this model can be applied to a wide range of services by using general-purpose AI. Services that use AI are increasingly automating customization for specific customers.

Another important point is that the use of AI makes services more outcome-oriented. In the past, suppliers were only able to offer their own products and associated services. A supplier of production machinery, for example, would also have supplied repair and other maintenance services. However, customer issues have a hierarchical structure. This hierarchy extends from top-level issues that directly influence the outcome of customer profits to more indirect low-level issues[30]. Wireless communication operators, for example, face the issues of operating their network successfully and attracting customers that influence profit directly, and also low-level issues such as the appropriate construction of the physical layer. While higher profits can be achieved if solutions can be provided to top-level issues that influence outcomes directly, the delivery of higher level solutions is difficult

*2: Google is a trademark of Google Inc.

when limited only to the company's own products.

This is a situation where the benefits of a general-purpose AI can be utilized. If a general-purpose AI can be connected to existing systems to obtain input data, outputs with value to the customer can be obtained from customer outcomes. To achieve this, a company must not be bound by its own products during system implementation. There is greater potential for winning large orders through the orchestration of a wide range of products, including those from other suppliers.

## CORPORATE ORGANIZATION IN THE ERA OF AI

AI enables services that generate ongoing innovation, with businesses that use AI being outcome-oriented. Accordingly, they require viewpoints and actions different to those of traditional product or service organizations. Organizations will need to undertake the following three reforms.

### Reform of Frontline Organizations

The first is the reform of frontline organizations. There is a need for frontline staff members and organizations that can engage with and market to customers in ways that derive from outcomes.

The concepts associated with this are significantly different from those of traditional product-based negotiation and marketing capabilities. Two externally evident differences are the need to ask customers about the outcomes they want and what outcomes to use to evaluate the success of the solutions to these challenges. There is also a need to discuss the value of suggested outcomes and how this value relates to their associated investment and other costs. This will require consultative abilities to avoid outcomes that are not likely to provide a cost-benefit and choosing outcomes that are likely to be beneficial.

Furthermore, existing sales staff members and system engineers will initially have no appreciation for the flexibility of general-purpose AI. Accordingly, even after they have succeeded in identifying new requirements from customers, they will tend to be hesitant about adopting unproven methods. This is because they are used to the rigid view of products and marketing practices of the past.

The revolutionary feature of general-purpose AI is that it can be used for many different functions simply by changing the input configuration. The value of this will be wasted if the technology is limited only to proven applications. Conversely, even in what appears to be proven applications, if different data is used, the results will be completely different. Customers also need to be made to understand this possibility.

There is a need to reform staffs and organizations to provide opportunities for training and practice so that these things can be utilized in practical marketing.

### Reform of Integration Organizations

The second is the reform of integration organizations. There is a need for flexibility that goes beyond the past practice of system integration (SI) driven by customer specifications.

General-purpose AI can transform the mechanistic IT and other equipment of the past into IT and other equipment that can learn and grow. Infinite possibilities are made available by combining this general-purpose AI with conventional IT and other equipment, and it has the power to generate significant value for customers. These IT and other equipment systems do not distinguish either between in-house and outsourced products, or between existing and new installations. Value can be generated through diverse combinations of AI with these in-house, outsourced, existing, and new installations.

To begin with, the combination of AI with existing IT and other equipment opens up opportunities for new services. In the past, maintenance services for IT and other equipment have been an important business. An ongoing and reliable source of income can be created by augmenting an equipment business with maintenance services. General-purpose AI takes this a step further. It is possible to achieve ongoing increases in asset value by integrating a general-purpose AI with existing equipment and IT. This is because it enables a steady progression of new management and business challenges to be dealt with in an ongoing manner by changing the configuration.

In the distribution warehouse example mentioned above, scheduling functions able to adapt flexibly to fluctuations in supply and demand or variations between staff were added to an existing WMS by connecting it to a general-purpose AI. New functions that in the past would have needed to be added to the WMS were instead achieved by adding a general-purpose AI. Furthermore, daily changes in circumstances are identified automatically from data and control logic that are updated automatically. Once the connection is in place, the optimal allocation of a wide range of people, goods, and money related to WMS data can be achieved simply by changing the AI configuration. Ongoing improvements to system functions can be made in accordance with operational and managerial requirements.

Here, the connection of a general-purpose AI is of great significance for the business regardless of whether it is an in-house or outsourced product. This is because it expands opportunities for working with customers by using IT and other equipment from other suppliers.

Consider also the significant expansion in the scope of products that can be offered when marketing new IT and other equipment. It is possible to offer new systems that learn about and react to changes in circumstances by combining a general-purpose AI with in-house and outsourced IT and other equipment products. Achieving this requires the establishment of an ecosystem or other network that includes products from other suppliers as well as in-house products.

For the new solutions using general-purpose AI described above, both staff members and organizations need the flexibility to combine a wide range of products and AI. Supporting this requires an ecosystem for a diverse range of companies capable of supplying an extensive range of products and services to exchange information and facilitate orchestration across products.

### Reform of Platform Organizations

The third is the reform of platform organizations. There is also a need to reform platform organizations in order to enable the first and second activities described above.

The first requirement is to raise the level of technical hierarchies handled by platforms. The platforms for the ongoing improvement and operation of general-purpose AIs and their configurations will handle management outcomes at a much higher level than the servers, storage, databases, operating systems (OSs), and operational middleware platforms used in the past. There is a need to change the mindset of people who have performed past hardware, software, and other development in accordance with specifications. Moreover, this means that customer outcomes will become easier to understand, including for the people responsible for platforms. They will serve in roles where they deal more directly with customers. It also means being able to contact people with greater decision-making authority. In both cases, it will put them in situations that are more rewarding. One obstacle to this is anxiety and fear of change. This will likely need to be dealt with in an organizational manner.

Dealing with higher level matters means greater exposure to change. It requires an organization in which 100 new AI applications each month commence operation using new configurations and that is able to incorporate the subsequent new requirements into the platform. This will require the establishment of practices that are capable of high rotation in a more agile and DevOps[h] manner than past low-level platforms[31].

The aim of the above three reforms is simple. It is to transform organizations into ones that generate innovation. According to Peter Drucker, the purpose of companies is to create customers. Innovation is the act of generating new demand for this purpose.

### Example of Organizational Reform: Reform of Hitachi

The new business structure adopted by Hitachi in April 2016 provides an example of the form taken by organizations for services that use AI[32] (see Fig. 11). In place of the previous product-oriented company structure, it is made up of customer-driven frontline organizations together with horizontal service and platform organizations and product organizations. For the frontline organizations, the aim is to create a business structure that generates innovation alongside customers by setting up 12 business units (BUs) to improve frontline functions such as sales, engineering, and consulting in four markets: (1) Power/Energy, (2) Manufacturing/Water, (3) Urban Development, and (4) Finance/Public/Healthcare. Hitachi also set up service and platform BUs that consolidate and integrate the technologies essential to providing advanced services, including AI, analytics, and control technology, to create a business structure that supplies open common platforms to the frontline BUs and other partners. The product-focused businesses supply components, materials, and other products to the frontline BUs and other customers.

In this way, moves to reform organizational structures can be expected to become more widespread in the future along with the emergence of the innovative technology of AI.

## CONCLUSIONS

This article has presented an overview of AI, which has a potential that goes beyond just advances in computing. As a new methodology for humankind, AI dramatically enhances the ability of companies and people to respond amid the unpredictable changes in

(h) DevOps
A term coined from the combination of development and operations. It is a method for developing systems that adapt more quickly and flexibly to business challenges through cooperation and collaboration between the people responsible for development and operations.

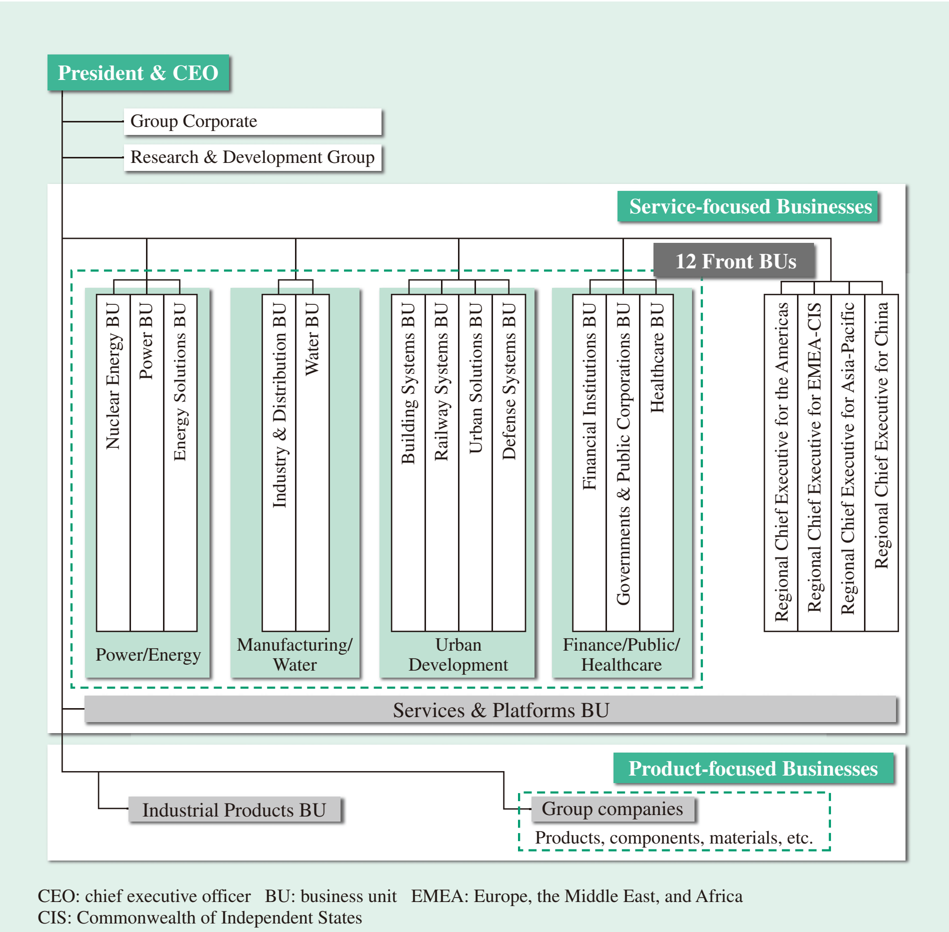


*Fig. 11—Example Organization that Uses AI (Reorganization of Hitachi).*
*AI plays an important role in Hitachi's new structure made up of customer-driven frontline organizations together with horizontal service and platform organizations and product organizations. The reorganization took place in April 2016.*

the environment that are occurring globally. The power of this new way of doing things will grow rapidly over time compared to previous practices that relied on the capabilities of individuals. This trend will extend across all industries and types of work. The author refers to this as the general adoption of AI.

Nevertheless, AI is a methodology for humankind. Its purpose is to increase the ability of people to solve problems and it is the task of people to decide which problems to solve, a process that calls heavily on experience and intuition. This will enable people to take on challenges they could never have imagined in an unpredictable world. The creation of the unknown future is something we can start today.

After being paralyzed on her left side by a stroke at the age of 77, the sociologist Kazuko Tsurumi wrote a poem about encountering a world she had been unaware of when healthy.

> Small universe, named I, resonates in the large universe
> The sound it makes is new every day[33]
> (Author's translation)

The poem expresses, with a grand sense of scale, the feeling of contemplating the unknown world prompted by the trials of a disability.

In acquiring AI as a new way of confronting the unknown, can people investigate new things every day? People want to progress by routinely making new investigations into the unknowns faced in corporate strategy, business operations, national policy making, and the lives of individuals. This approach by people is likely to be always creative in facing the possibilities of the unknown while also being incomplete. The author would like to be like this.

> Completion consists of being forever incomplete
> (Kenji Miyazawa 1926[34]) (Author's translation)

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