The advance of artificial intelligence

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The arrival of Artificial Intelligence – and how it will impact on our lives

Today we are seeing the true emergence of a powerful new digital technology: Artificial Intelligence (AI). Previous waves of digitalization have brought us ubiquitous broadband and mobile connectivity, giving internet access to billions of people around the world, while the Internet of Things (IoT) has opened the door to a wealth of data about the world around us. But now, through creating real-time dialog between things, people and information, we are entering a hyperconnected era in which we will apply AI in real, everyday business situations. The world will not be the same again.

Although people may not immediately realize it, AI and associated technologies such as neural networks have in fact already become an integral part of our daily lives. Anyone who has ever used the digital assistant on their smartphone has experienced the natural language interface we use to communicate with chatbots, while we're also accustomed to facial recognition capabilities, with these now commonplace, for example on Facebook and in pictures taken by smartphones.

A great example of AI in action is in scanning vast amounts Internet traffic in real time, helping identify potential cybersecurity threats that have never even been seen before – which allows us to take mitigating actions before a threat has taken hold. For humans, it would be simply impossible to scan through hundreds of thousands of internet logs to spot the precise pattern that could signal a cyberattack.

In the medical field, a number of trials have shown that AI can also be trained to identify anomalies – for example, to differentiate cancer cells from normal cells in biopsies. AI is helping us apply science to something that previously relied on the human eye. In many cases, from handwriting recognition to passing math exams, AI has already proven more accurate than human experts.

That's not to say that humans will be replaced by machines. Fujitsu believes that harnessing these new-generation technologies will be hugely empowering for people. The impact of AI on our lives is not something that we will notice or appreciate overnight, but one thing is clear: Its progress is constant, and inevitable. It's only when you step back that you see how far we have already come, and that you can appreciate the journey ahead of us. With machines able to tackle more and more of the mundane tasks, people can better focus on areas that add more value. It is people who remain at the center of Fujitsu's vision, with AI solutions centered around creating value and supporting the work they do.

# What exactly is Artificial Intelligence?

A problem with finding a definition for AI is that we are still not sure exactly what real, human intelligence is. A simple view would be to describe it along the lines of "the simulation of human intelligence by machines". In other words, AI relates to getting a computer to reason and to learn, and then to use this thinking as the basis to make decisions.

AI systems are excellent at pattern recognition. This means they can quickly spot anomalies and make predictions, often more consistently, more accurately and more reliably than humans. However, AI systems today are limited only to that. They essentially use probability and logic to make their analysis, but lack the ability to understand or be able to develop broad context in the way that humans can. Such an ability, which we could also call 'general intelligence', is still a long way off from current technologies … and may never be realized at all.

Unlike most traditional computing structures, today's AI systems are not centered around massive, complex central processors. Instead, they are based on neural networks, modelled loosely on the human brain – with a large number of processing elements or nodes that manage the flow of information between one another.

In computer science, AI is not a single, well defined entity, instead it incorporates many capabilities, models and methods. However, three elements in particular account for the huge acceleration and advances in AI of the past five years:

■ **Machine Learning** – a set of techniques (including many different types of algorithms such as reinforcement learning, rule-based machine learning and decision trees) that enable machines to learn from data, without being explicitly programmed for the task at hand.
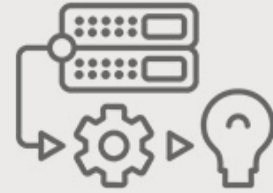
■ **Neural Networks** – a computing model that arranges large numbers of processing nodes, from tens of thousands to millions, linked by an even larger number of connections, in a way that resembles how neurons and synapses are arranged in the human brain. The power of the system does not come from the individual nodes themselves, which use algorithms to carry out only simple tasks of forwarding information to other nodes, but is derived from the layered architecture of the neural network as a whole, which becomes adept at recognizing complex patterns.

■ **Deep Learning** – a machine learning technique that exploits the architecture of a neural network with several layers, some of them possibly specialized for certain characteristics and patterns. For example, deep learning can be used to recognize a picture of a cat (the iconic task of image recognition). A typical neural network is six or seven layers deep – while the number of layers in the most sophisticated networks now runs into the hundreds. At the deepest level, neural networks look at individual pixels, while higher levels identify elements like the tail, paws and ears – and the cat itself. The technique requires data – and lots of it – to work, but having been trained by looking at thousands or even millions of pictures, a neural network becomes very good at its task, better even than a human.

The real power is that the system only needs to learn once. Once learned, the system's knowledge (for example, 'what does a cat look like?', 'what do normal data packets (as opposed to a security breach) look like?' or 'what does an unhappy customer look like?') can be transferred to other applications, where this learned recognition can provide instant help in making decisions or recommending intervention. In some cases we even can use transfer learning, where not just the "how" but also "what" has been learned can be re-used, even if the task is a different one.

It is also worth noting that we often bundle other technologies, such as robotics, into the same conversation as AI. That's because AI and robotics are such complementary technologies, with AI enabling automated decision-making and robotics enabling the decisions to be fed into physical actions. For instance, autonomous (self-driving) vehicles are the result of combining AI and robotics.

The application of intelligence

Artificial intelligence is hugely powerful – there is a real possibility that it is the most powerful technology we have ever created. Once something is learned by a machine, it doesn't need to be learned again – just like how a human will never forget how to ride a bicycle.

The true power of AI lies in how this intelligence is applied. You can use AI to derive significant benefits from unsophisticated data sources, for example in monitoring CCTV feeds to to manage traffic flow in cities, to spot suspicious individuals in public places, or to enable crowds from sports matches or concerts to disperse more efficiently, through guiding people to the most convenient exit or mode of public transportation.

Although these may not be immediately noticeable, the use of AI is already delivering improvements to our daily lives. Machine learning can enable a moving tractor to tell the difference, in real time, between a growing lettuce and a dandelion – and then apply a targeted dose of weedkiller – giving the lettuce more space to grow, and delivering a more efficient crop yield. AI can also help determine the optimal time for harvesting – making more informed, intelligent decisions by studying weather patterns and historical data, as well as factoring in data from other sources, such as current levels of supply and demand in local supermarkets.

Supply chain management is also significantly enhanced by the use of AI – which can monitor inventories across entire production lines to make sure that supplies of essential components are never in danger of running out, and therefore avoiding expensive downtime. It's difficult for human operators to do this efficiently across entire production lines – and of course they are prone to human error – but this is perfect for AI, as machines never sleep, need a coffee break, lose count, or get distracted.

Fujitsu's human centric view is that AI will make humans more effective. Thanks to the assistance of AI, humans become able to work more efficiently, and can focus on higher-value activities. This is exactly what the next wave of robots to arrive on the shop floor is helping us to achieve. AI can help us make food production and supply chains so efficient that no food ever goes to waste. In medicine, AI can help doctors rapidly make preliminary diagnoses, freeing them up to spend more time to address each patient's specific issues. And customer experiences can be enhanced when AI tackles simple tasks, giving customer-facing staff more time to deal with complex cases.

With all the potential benefits to be gained, and mountains of data to be leveraged, we are often asked when is the 'right' time to adopt AI. Every customer's case is of course unique and AI is still in its infancy: however, it is already clear from the examples above that early adopters will gain a competitive advantage.

AI Zinrai: Fujitsu Artificial Intelligence

The Fujitsu brand for AI is Zinrai – a framework to bring together diverse development threads and AI techniques. Zinrai itself is not a product or a service, but a collective framework for the broad family of AI capabilities that Fujitsu is making available to our customers. These add a wide range of value-added services to the Fujitsu MetaArc portfolio, which is focused on enabling customers to digitalize with confidence.

Zinrai takes a Human Centric, Solutions Driven approach to co-create valuable offerings for our customers using the best of breed technologies from across the globe, developed and deployed to meet ever-growing customer challenges. Combining the strength of Zinrai AI development in Japan and the rest of the world with carefully selected partner capabilities, Fujitsu delivers the optimal, AI supported solution to our customers' challenges.

Fujitsu and AI

Fujitsu has been actively involved in developing and deploying AI and associated technologies for decades. One example of the results is a set of significant innovations in the recognition of handwriting – while machine recognition of individual Chinese characters had already exceeded human capabilities, computers still struggled to accurately understand strings of characters. A recently-developed Fujitsu AI model achieved the world's highest degree of accuracy in recognizing these strings of Chinese characters – greatly improving the effectiveness of digitalizing handwritten texts.

Since AI has enormous computer processing requirements, particularly in the learning phase, Fujitsu Laboratories has been working to maximize the computational horsepower available to neural networks. Much of this expertise has been gained from our unrivalled pedigree in the field of supercomputing. Back in 2011, Fujitsu built the K supercomputer, based on a distributed memory architecture comprising of more than 80,000 computer nodes. The work undertaken in this field greatly advanced Fujitsu's understanding of how to link computing nodes, a key characteristic of the underlying technologies of AI. The processing capability has been put to good use – for example, K is used by the Riken Advanced Institute for Computational Science based in Kobe, Japan, to predict and solve problems in fields including climate research, disaster prevention and medical research.

Other developments have included:

- Streamlining the memory efficiency of graphics processing units (GPUs) and optimizing associated algorithms, making it possible for neural networks to use parallel processing more effectively. This has successfully doubled the speed of learning for neural networks, based on the widely deployed AlexNet and VGGNet research networks.

- Producing and optimizing field programmable gate arrays (FPGAs) to speed up processing, by directly executing commands in computer hardware. One recent implementation was shown to be 10,000 times faster than conventional computers.

Ultimately, the secret to any successful AI implementation is creating a foundation based on an excellent systems design – an area where Fujitsu has considerable expertise.

Tranforming industries

In the business world, AI is transforming many industries thanks to its ability to identify patterns, adding a new dimension by detecting anomalies in mountains of digital information. Once trained, it is tireless in processing many standard tasks. For example, the addition of AI to service desks and call centers is freeing up staff from low-level, monotonous tasks, enabling them to concentrate instead on addressing more complex technical problems, or complicated requests, or delivering better customer experience or care.

One of the true strengths of AI is where patterns of any kind are involved. **Financial institutions** are using AI to model the potential direction of stock markets. AI is also extending the capabilities of analytics platforms. For instance, Fujitsu has undertaken a proof of concept to analyze signatures, helping to detect fraudulent patterns. We are also talking to banks about the use of facial recognition in ATMs, not only to improve security but also to personalize services.

Healthcare is also starting to take advantage of the benefits of AI. Since this is a field that generates large quantities of clinical data, AI is perfectly suited to extracting insight by analyzing this input. For example, Fujitsu's advanced clinical research information system HIKARI (a word that means 'light' in Japanese) uses AI to provide clinicians with insights that can aid their decision-making: a perfect example of human centric innovation and how AI is helping create value for people and society.

AI will also revolutionize the **transport** sector – as the brains of autonomous (self-driving)
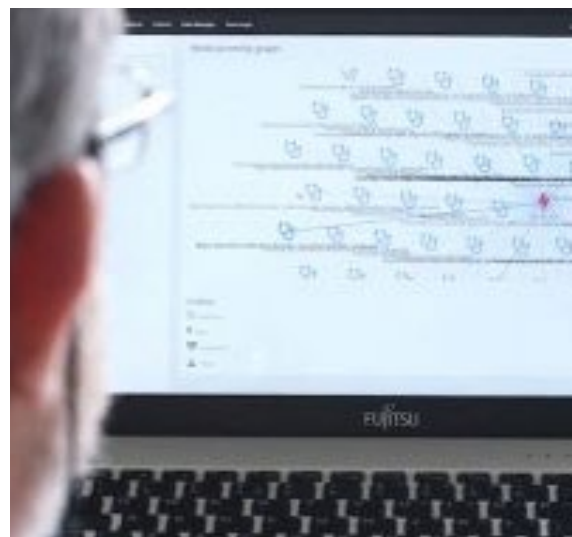
vehicles. Among the early wins in this field are logistics companies, who can already optimize delivery routes in real time to avoid delays caused by traffic congestion.

Manufacturing is also benefiting from AI, with machines taking on monotonous tasks such as looking for defects in product manufacturing. Not only does machine learning improve the level of accuracy, but also it reduces the time to analyze results. What's next is predictive maintenance, for instance in identifying the likelihood of product failure in the field.


When built, the Fujitsu K supercomputer was the fastest in the world. Although it has since been overtaken by a select few, K – named after a Japanese word meaning 'to the power of sixteen' – is still the outright leader in multiple processing benchmarks, thanks to fine-tuning of its original system design.

In 2015, Fujitsu's AI system achieved a 96.7% recognition rate for Chinese handwriting characters – more accurate than humans for the first time.
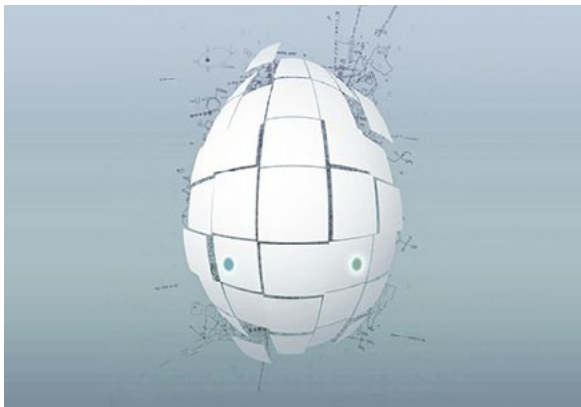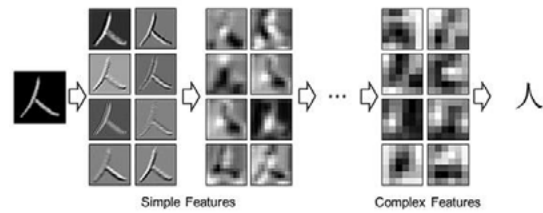
In 2016, the Todai Robot, which Fujitsu helped work on, reached the standard required to pass the math part of the entrance exam to Tokyo University
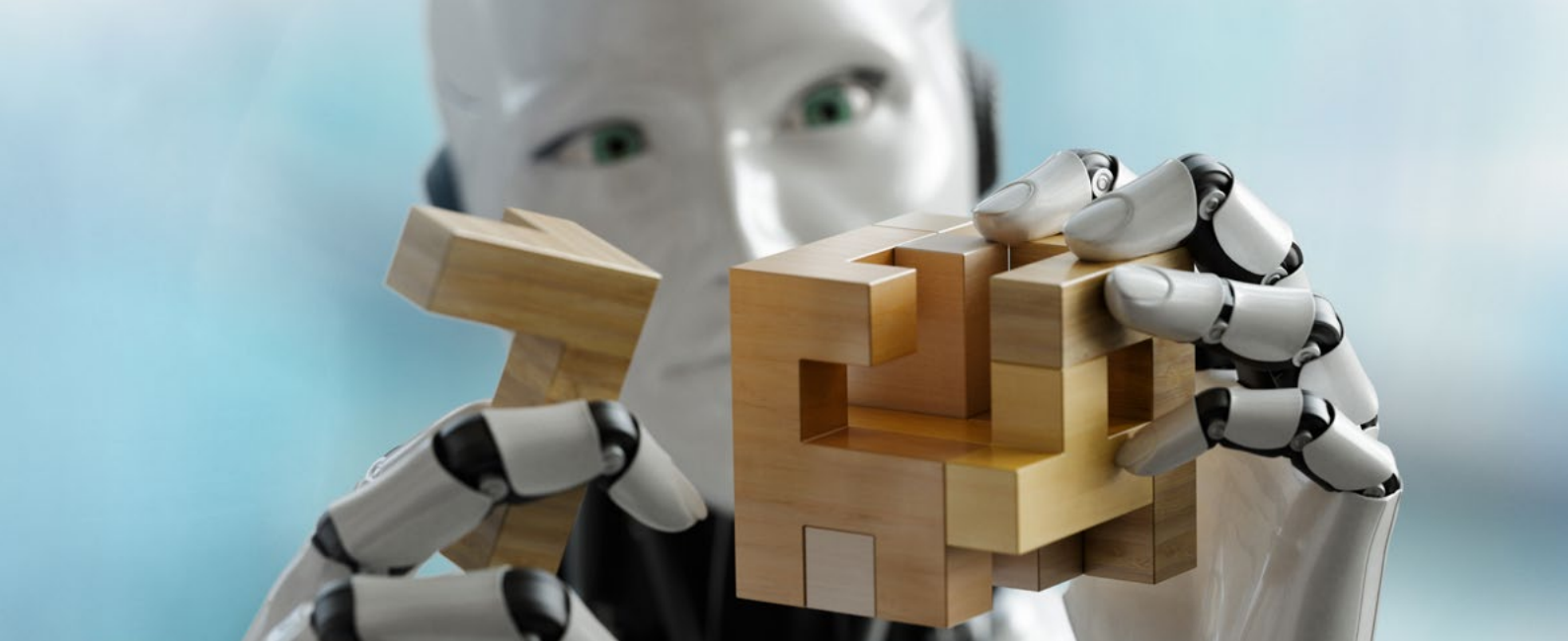
From processing to problem solving

We have been moving rapidly away from using AI for abstract processing, to using it to solve specific problems. In parallel we are expanding the use cases where AI can be applied.

One key to unlocking the future potential of AI will be how we can play to its strengths. At Fujitsu, we've been working to harness the ability of AI to recognize patterns and images by turning data into images. By implementing what we call 'imagification', we have been able to apply AI this to challenges that are typically not image-based. Using this technique, we have used AI to interpret the movements received from a small accelerometer worn on a car driver's wrist. We've done this by plotting the movements on a chart and training the system to differentiate between different types of movement. This could potentially be used by insurers to identify safe drivers.

As we've seen, today's AI systems are highly adept at pattern recognition but are far less capable of understanding context. This becomes clear when you try to have a conversation with a system that has been designed to identify key words in speech. As a result, the days of 'conscious AI' are some way off. However, we are only just scratching the surface of potential implementations – in twenty years' time when the technology has really matured, we expect it to have totally transformed every industry, from healthcare to retail to financial services.

Why is now the time for AI?

The idea of using AI in solving problems is not a new one – in fact it has been discussed since the 1960s. What has changed recently is that we now have an environment that makes AI a possibility.

- Computers and processors dropping to a price point that has enabled the construction of large neural networks.
- Massive amounts of data at our disposal – providing more information that we can use to train neural networks (it is no coincidence that many early trials were based on photographs of cats on the internet…).
- New techniques, architectures and algorithms that enable these two devlopments to be exploited.

We already interact daily with instances of AI – as mentioned earlier, with systems such as Siri on our mobile phones, and with customer service bots that can help us with everything from finding cost effective flights to searching Google. Most call centers now use AI to power their voice recognition systems.

Accelerating medical care at San Carlos Hospital

A great example of how AI can bring new value is the collaboration between Fujitsu and clinicians at San Carlos Clinical Hospital in Madrid, Spain. This highlights the importance of finding new ways to support the clinical decision-making process.

The use of AI has minimized the time required for diagnosis of psychiatric patients. Traditionally, the process involves doctors going through patient histories, researching information from many other different sources and consulting with colleagues. This can take many hours, in a field where a timely diagnosis is critical to prevent dangerous outcomes developing for the patient.

> **By enabling AI to pre-screen patient records, clinicians can not only spend more time with the patients themselves but they can delve even deeper into understanding the causes and outcomes of the conditions of mental illness**

The Fujitsu AI engine analyzed 30,000 secure and anonymized patient records, combined with analysis of public health data to recognize patterns in the cases and the type of outcomes that arise for patients. Having learned using this data, the system is now capable of rapidly analyzing new patient cases and identifying risk factors. It flags up likely health risks for a patient, such as alcohol or drug dependence or even a risk of suicide. The hospital estimated the system was 95 percent as accurate as a team of experienced doctors in assessing each case. By enabling AI to pre-screen patient records, clinicians can not only spend more time with the patients themselves but they can delve even deeper into understanding the causes and outcomes of the conditions of mental illness.

The success of this field trial has been key to developing a new Fujitsu Health API, which leverages advanced AI to benefit society.

(i) Further information

- Fujitsu's Human Centric AI vision: http://www.fujitsu.com/global/vision/human-centric-ai/

- Fujitsu's 2017 Technology and Service vision: http://www.fujitsu.com/global/microsite/vision/

- AI posts on the Fujitsu blog: http://blog.global.fujitsu.com/?s=artificial+intelligence

- Fujitsu develops Human Centric AI Zinrai system: http://pr.fujitsu.com/jp/news/2015/11/2.html

- Is artificial intelligence smarter than we are? AI system achieves world-record 96.7% handwriting recognition on Chinese characters: http://journal.jp.fujitsu.com/2015/10/02/01/