Pervasive Artificial Intelligence

Yuji Nomura

Abstract

Widely accessible advanced machine learning will result in the expanded use of artificial intelligence (AI). AI will increase convenience, resolve intellectual labor shortages, and drastically advance science. Consequently, mastering AI will become a critical component of competitiveness.

Keywords: artificial intelligence, deep learning, machine learning

1. Pervasiveness of deep learning

In 2016, the big news on artificial intelligence (AI) was the major developments in the technology known as deep learning, which mimics the brain cell activity of animals. Deep learning is expected to have higher accuracy than past AI technology and feature extraction, which can also be automated, making it available to a wider range of users. In addition, open environments and open source software are resulting in accelerated advancements in deep learning, and TensorFlow, DSSTNE (Deep Scalable Sparse Tensor Network Engine), CNTK (Microsoft Cognitive Toolkit), and other frameworks and cloud environments for deep learning have been created, further enabling its use. For specific applications such as image recognition, there are now web services that let users perform deep learning and even prediction without programming.

The use of deep learning is rapidly becoming widespread. For example, farmers are using AI to recognize and learn images of cucumbers and to distinguish ratings of crops, and dermatologists are using AI to recognize and learn images of symptoms and diagnose skin cancer. In the future, the use of deep learning is expected to become even easier, and commoditization will likely follow.

2. Expanding AI applications

AI applications are expanding in various fields by leveraging deep learning. AI is already used in healthcare for diagnosis and drug discovery, in finance for stock trading and credit decisions, and in retail for marketing and customer service. In addition, AI technology supports our daily life in things we take for granted such as web search, path search, and translation activities. Thus, AI will most likely spread to all fields in a natural way.

Robotic process automation (RPA), a system that enables digital robots operating with rule engines and AI to automate white-collar tasks, is also becoming popular. RPA automates tasks without the need for programming, and it is currently used to perform rule-based automation of routine tasks. However, it is believed that advanced AI will be used to automate more sophisticated, non-routine tasks such as analysis and decision making in the future. Some predict that more than 100 million global, full-time intellectual workers will be replaced by AI by 2025 [1]. This will likely contribute to the resolution of labor shortages.

AI is also being tried in research applications. For example, AI was able to reproduce the condition of a gas that requires complex control and that is difficult to reproduce. AI used a method that would never occur to humans and completed the task in an hour [2]. Soon, AI may advance rapidly in research-based fields such as science and physics, enabling dramatic progress.

3. Further evolution of AI technology

AI is rapidly advancing in image and voice recognition, and it is still evolving in other areas. One of these areas concerns the understanding of meaning. In addition to using text to explain the contents of an image, some researchers have recently been actively

trying to generate images based on text, thereby generating images that are close to the *meaning* of the text. Inter-exchangeability between language and images may mean that AI is getting close to understanding meaning.

Another area of evolution has to do with the issue that large amounts of teaching data are necessary for AI to learn. Humans have a natural ability to learn inductively based on events that occur and to identify an object after it has been taught only once. Technology called *deep reinforcement learning* is attracting attention as a potential way to mimic this ability. Reinforcement learning is the autonomous learning of subsequent actions to take or the condition that needs to exist based on experience. Deep reinforcement learning combines reinforcement learning and deep learning. With this technology, there is no need to provide in advance the teaching data necessary for machine learning. All that is required is to set up the desired actions and conditions. AI will then use repeated trial and error to learn the task. This technology is already used in AlphaGo, an AI *go* playing machine that surprised the world by beating a professional *go* player in 2016. It is also being used in self-driving cars and in robots used in factories.

Many studies are underway to make machine learning possible based on small amounts of teaching data for tasks to which reinforcement learning cannot be applied. The fundamental concept of this is called *transfer learning*, where the knowledge acquired when learning one task is applied to the learning of another, streamlining the learning process. For example, in an image categorization task with limited amounts of data, teaching just one image from a category that AI had not yet learned enabled it to achieve a level of accuracy that was almost equivalent to a case where large amounts of data were taught. If this technology is implemented, AI is expected to learn things and events at a dramatic speed, further expanding its use.

4. Importance of knowledge and technology of AI utilization

While the advancement of deep learning is remarkable, it is not versatile. Therefore, it is critical to understand the advantages and disadvantages of deep learning before identifying its application areas. Under some circumstances, rule bases, probability/search models, and other traditional algorithms may have to be selected. For example, in standard chess, humans cannot beat AI. However, in advanced chess, collaboration between AI and a human achieves better results. Therefore, it is critical to identify the areas and the best method for such collaboration.

Since technologies such as transfer learning, where small amounts of data enable learning, are under development, large amounts of learning data are still necessary to achieve a practical level of accuracy for AI in a new area. For this reason, it is necessary to determine how much learning data can be acquired in advance, and whether or not a system can be built that can perpetually accumulate data during operation based on feedback. In addition, preprocessing such as data cleansing, and the know-how on parameter tuning are important to achieve high accuracy. Machine learning has reached a point where a certain level of accuracy can be achieved. However, the knowledge and technology for utilizing AI will be a critical differentiator for companies in the future.

5. Toward AI that further contributes to humans

Deep learning is based on complex network structures similar to actual brain neurons. The high accuracy achieved with deep learning has become possible thanks to improvements in computer processing. At the same time,

the process to obtain the answer has also become more complex, making it difficult for humans to understand the judgments and reason for the end result. This is one of the challenges of deep learning.

For instance, when humans look at an image of an elephant, they can recognize it as such, although they are probably not making a judgment based on logical reasoning. However, if they are asked for their reasons for deciding the image is an elephant, they site details such as its long trunk and huge ears. Thus, just as humans can explain the reason after the fact, AI may be able to provide accurate explanations for the process it uses to reach its decision.

A project is underway that aims to enable the explanation of the basis of output results [3]. If AI can acquire the ability to explain its judgment and reasoning in the future, it will be easier to improve accuracy and apply it to cases where human lives are involved, such as in self-driving cars.

Discussions are also underway on the singularity of AI's abilities to exceed those of humans. Many non-profit organizations have been established with the purpose of keeping AI from becoming private and abused, developing AI to contribute to society, evaluating AI's impact, and establishing development principles [4]. Social, ethical, and legal issues sur-

rounding AI will need to be resolved. These efforts will increase in importance in the future. Although AI is not yet fully developed, it is important to discuss its development and effective use as well as its risks now. Doing so will contribute to the benefits of using AI for humans, such as the resolution of labor shortages and energy issues.

References

[1] McKinsey Global Institute, "Disruptive Technologies: Advances that Will Transform Life, Business, and the Global Economy," May 2013. http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies

[2] P. B. Wigley, P. J. Everitt, A. van den Hengel, J. W. Bastian, M. A. Sooriyabandara, G. D. McDonald, K. S. Hardman, C. D. Quinlivan, P. Manju, C. C. N. Kuhn, I. R. Petersen, A. N. Luiten, J. J. Hope, N. P. Robins, and M. R. Hush, "Fast Machine-learning Online Optimization of Ultra-cold-atom Experiments," Scientific Reports 6, 25890, 2016.

[3] D. Gunning, "Explainable Artificial Intelligence (XAI)," http://www.darpa.mil/program/explainable-artificial-intelligence

[4] Open AI, http://www.openai.com/
Partnership on AI, http://www.partnershiponai.org/
Ministry of Internal Affairs and Communications, AI Network Social Promotion Conference (in Japanese), http://www.soumu.go.jp/main_sosiki/kenkyu/ai_network

Trademark notes
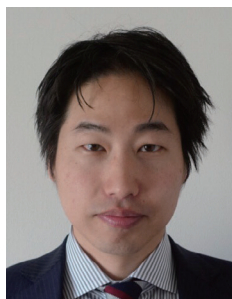
Yuji Nomura
Deputy Manager, Strategy Development Section, Research and Development Headquarters, NTT DATA Corporation.
He received an M.S. in science and technology from Keio University, Kanagawa, in 2005. Since joining NTT DATA in 2005, he has researched and developed a text processing technology system centered on information extraction technology. He is a member of the Information Processing Society of Japan.