Perspectives on Artificial Intelligence/Robotics and Work/Employment

Acceptable Intelligence with Responsibility

Preface to the English translation

Japan is facing the super-aging of society and it is estimated that by 2025, more than 35 million people (about 30% of the population) will be over 65 years old. Under such circumstances, it is often said that the Japanese are more optimistic about introducing artificial intelligence (AI) and robots to the workplace, in contrast with other countries, who are more concerned about the possibility of machines taking over jobs currently performed by human beings.

However, the workplace in Japan will not immediately be taken over by machines. Technology and society are mutually related, so we must closely examine how each research area is interacting with ethical, legal, and social issues. In addition, experts in domains such as healthcare and agriculture are also carefully reorganizing their tasks through the use of AI and robots and negotiating numerous variables in the process, such as institutions, organizational cultures, economic efficiency, and human values. These practices can be seen all over the world, not only in Japan; however, there is not as much information on Japan's practices in this regard due to the language barrier. We hope that this report will contribute to an understanding of Japanese technological, institutional, cultural, and social aspects on AI and robotics.

The original report on this topic was published in Japanese as part of the *Research Materials* series of the "Science and Technology Research Project" of the Research and Legislative Reference Bureau (RLRB), the National Diet Library. The RLRB is responsible for providing the Diet with legislative research and information services and is an associate member of the European Parliamentary Technology Assessment (EPTA), an international network of parliamentary science and technology policy institutions. In the "Science and Technology Research Project," the RLRB cooperates with outside experts to conduct research on topics related to key national policy issues pertaining to science and technology. The results of the research are published and distributed to Diet members and other relevant parties, as well as to the general public online. The "Science and Technology Research Project" aims to provide assistance for legislation, therefore, the information should be provided in ways that are as objective and nonpartisan as possible, and without supporting any particular policy.

The report, "Perspectives on Artificial Intelligence/Robotics and Work/Employment," was conducted as a "Science and Technology Research Project" in FY2017 and was published in March 2018 in Japanese. In May 2018, policy seminar pertaining to the report was held for Diet members, parliamentary staff, and others involved in the Diet.

The chairs of the report are members of a research group called Acceptable Intelligence with Responsibility (AIR: http://sig-air.org/), an ad hoc interdisciplinary network. The report was compiled through the ongoing exchange of opinions among twenty-three authors of varied specialties and affiliations. AIR activities include research and surveys, field studies, oral history projects and organized events. Some of the case studies of this report are the results of the AIR community. The English translation is licensed by AIR and AIR takes full responsibility for the translation of the report. In the process of translation, authors were asked to replace Japanese references with English materials, as needed, for the

convenience of readers. Comments from readers and further collaborative research opportunities from both the international and interdisciplinary realms are appreciated.

Acknowledgements

We would like to thank all authors for checking and adding information during the process of translating the report into English. We also want to thank Takahiro Enoki and Masahiro Endo from the Research and Legislative Reference Bureau, the National Diet Library for their careful reading and advice for the Japanese version and for their support for the publication of the English translation. We are also eager to thank all interviewees who participated in our case studies. We are also indebted to Mayumi Kawamura (*each*) for the attractive cover design. Finally, we are grateful to the Japan Science and Technology Agency Research Institute of Science and Technology for Society (JST-RISTEX) for their support.

Arisa Ema and Hiromitsu Hattori

Preface

Interest in artificial intelligence (AI) and robots has increased in recent years. There have been numerous studies on AI, robotics, employment, and labor, particularly from mid- to long-term perspectives, with various viewpoints—that these technologies improve productivity and create employment or that people will be deprived of work, the disparity in which is widening. This report investigates the state of adoption of AI and robotics, the state of investigations, and the issues that have arisen, and contributes to the discussion of employment and labor in a future AI, robotic society.

As it is difficult to cover all technologies relating to AI and robotics, nine research topics in three domains are focused upon. In part 1, "Research and Technological Trends," addresses fields related to (1) knowledge and data processing (knowledge processing / machine learning, natural language processing, image acquisition and recognition), (2) the boundaries between humans and machines (speech interface, human–agent interaction), and (3) daily life and industry (robotics, IoT, multi-agent systems, and crowdsourcing). With regard to each technical topic, (1) presents notable social background, (2) presents technology trends in Japan and overseas, (3) focuses on applications to actual society and promising fields of application, and (4) details social issues and topics expected to arise in the future.

In the discussion of AI, robots, employment, and labor, workplace actors that should be considered range from technology developers to end-users; however, part 2 of this report, "AI Trends by Domain," focuses on experts in each domain using AI and robots as tools for their work. Specifically, examples from Japan in eight domains are focused upon: (1) healthcare (doctors), (2) elderly care (care workers; however, it is important to note that the role families play is far from small), (3) art and design (creators), (4) education (teachers), (5) hospitality (customer service staff), (6) transportation / mobility (drivers), (7) agriculture (farmers), and (8) public order and security (police officers, security guards). Additionally, (a) AI applications for defense and national security overseas (military) and (b) trends in Japanese Chess *Shōgi* (*Shōgi* players) are also addressed as a column. This part treats technology as only one means of responding to social issues and focuses on interaction between technology and society. As such, each article in part 2 introduces (1) a broad perspective on the challenges facing Japan in each domain, (2) efforts taken by social institutions and policy to respond to these challenges, (3) usages of AI, robotics, and broader information technologies, and (4) ethical, legal, and social implications brought about by AI and robots, and issues that are difficult to solve solely by technology.

In part 3 "AI and Employment Overseas, and in Development, Utilization and Management of Human Resources," the first half outlines policy trends rating for AI, robotics, and employment in US, EU, Germany, France, and China, and the second half introduces the state of technology and human resource growth, utilization, and control in Japan and overseas. This report was compiled through the repeated exchange of opinions among twenty-three authors of differing specialties and affiliations (informatics, engineering, sociology, anthropology, analytic philosophy, information ethics, law, and science technology studies), gathering and organizing information including interview surveys carried out in each field.

Summary

Expectations of the benefits of artificial intelligence (AI) are rising. Being in the midst of the 3rd AI boom, we should be careful not to create unreasonable expectations. We should also not regard the current boom as transient, and consider AI as interacting and assimilating with society. Thus, understanding the possibilities and limitations of the technologies is necessary. For example, paying attention to not just boom-leading technologies, such as machine learning, which are directly related to the processing of knowledge and data in AI, but also technologies for human-machine interfaces, as well as those applying AI to industry and human lifestyles is essential. Along with an understanding of the social background, the technological trends, and the potential applications that have kindled interest in these technologies, social issues that would emerge from their application should also be considered.

It should be understood that the contentious issues and the reorganization of employment and workplace being attributed to cutting-edge AI technologies are often the result of conventional information and communication technologies. Therefore, identifying concrete examples of problems that have already emerged in the workplace is important. Workplace actors that should be considered range from technology developers to end-users; their relationships are relative because sometimes users will engage in research and development (R&D), and at other times, become data providers. Among these actors, the effects on labor and employment are already keenly felt by experts in industries, such as healthcare, elderly care, art and design, education, hospitality, transportation and mobility, agriculture, and security, where AI and robotics have been introduced in the workplace. Looking at concrete examples, the short-term effects of the introduction of AI and robotics should be characterized as the "substitution of tasks" rather than the "replacement of jobs."

AI improves its performance by learning from vast volumes of data, including image and audio. Therefore, organizing data by considering personal privacy protection, including privacy issues and data biases, is necessary. Moreover, AI does not stand alone but functions within infrastructure, such as communication networks and hardware. It also interacts with communities, institutions, economics, human values, and organizational culture; this means that AI might not necessarily be used as intended by its developers. Currently, R&D guidelines for the AI developers are discussed. However, we also have to widen our perspectives on how domain experts reorganize their tasks by using AI and robotics in the workplace based on the performance and limitation of the technologies, social contexts, and human values.

The employment and labor issues related to AI and robotics vary according to the country, region, and sociopolitical context considered. Many countries, including Japan, consider them to be a pillar of industrial growth and economic development but in enhancing both the economic rationale and efficiency of their performance, the environment and human work styles are sometimes altered. This may pose the risk of nudging and restricting workers' and consumers' behaviors. Further, the environmental and health impact should be considered. Therefore, we need to educate not only AI- and robotics-skilled people, but also those who understand the ethical, legal, and social implications of properly introducing AI and robotics to our society.

Perspectives on Artificial Intelligence/Robotics and Work/Employment
Contents

Introduction

Society holds high expectations for the benefits of artificial intelligence (AI). In Japan, under the instructions of the Prime Minister during the "Public-Private Dialogue towards Investment for the Future" held in April 2016, the "Strategic Council for AI Technology" was established. Under the leadership of the council, research and development and social implementation on AI were facilitated in cooperation and in coordination with the relevant ministries and agencies, including the Ministry of Internal Affairs and Communications (MIC), Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of Economy, Trade and Industry (METI), Cabinet Office, Ministry of Health, Labour and Welfare (MHLW), Ministry of Land, Infrastructure, Transport and Tourism (MLIT), and Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan.[1]

Expectations are placed on AI technology as an important foundational technology of "Society 5.0," for which the Japanese government is aiming; however, there is also concern over the impact of technology on human society. For example, both the "Report on Artificial Intelligence and Human Society" released in 2017 by the Cabinet Office and the "2017 Report of the Conference toward AI Network Society" by the Institute for Information and Communications Policy, under MIC addresses ethical, legal, and social implications concerning technology and put forth arguments about its influence on employment and work styles as economic implications.[2] The "New Industrial Structure Vision" by the New Industrial Structure Committee of the Industrial Structure Council of the METI has also considered changes in the industrial structure and employment structure, as well as the development of human resources, to be future issues.[3]

This report discusses how AI and robotics influence employment and labor. It will introduce how AI and robot technologies are used today, how they influence people's values, social systems, and laws under the perception that technology is just one of the methods for addressing social problems, and how technology and society interact with each other.

Many countries, including Japan, view AI and robotics as a pillar of their economic development and industrial policies. However, the social and political backgrounds and contexts in which AI and robotics are discussed regarding the issue of employment and labor vary by country. In Japan, for example, AI and robotics are positioned strongly as a solution to the aging population and the decreasing birthrate, as well as the associated decline of the labor force population.[4] On the other

---

[1] Strategic Council for AI Technology, "Artificial Intelligence Technology Strategy (Report of Strategic Council for AI Technology)," 2017.3.31, p.2. < http://www.nedo.go.jp/content/100865202.pdf >

[2] Advisory Board on Artificial Intelligence and Human Society, Cabinet Office, "Report on Artificial Intelligence and Human Society Unofficial translation," 2017.3.24, pp.1-2. < http://www8.cao.go.jp/cstp/tyousakai/ai/summary/aisociety_en.pdf >, Conference toward AI Network Society, Institute for Information and Communications Policy, Ministry of Internal Affairs and Communications, "Report 2017 - Toward Promotion of International Discussions on AI Networking," 2017.7.28, pp.1-2. Ministry of Internal Affairs and Communications Website < http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/Releases/Telecommunications/170728_05.html>

[3] New Industrial Structure Committee, Industrial Structure Council, Ministry of Economy, Trade and Industry, "New Industrial Structure Vision (Summary of Vision for New Industrial Structure)," 2017.5.30, Ministry of Economy, Trade and Industry Website < http://www.meti.go.jp/english/press/2017/0530_003.html>

[4] Strategic Council for AI Technology, "Artificial Intelligence Technology Strategy (Report of Strategic Council for AI

hand, in the United States and Europe, the growing disparity caused by the spread of AI and robotics has drawn particular attention.

Three topics will be introduced by cross-sectional perspectives that has been revealed in this report. In addition to this three topics, it is necessary to have further discussions on the jobs of "experts" (occupations) in each domain, as well as the significance of labor itself and its treatment when discussing the implications of AI and robotics on employment and labor in the future.

1. Will machines take away all our jobs? AI and robotics replacing humans beings' tasks

In 2013, associate professor of Oxford University Michael A. Osborne published a report with colleagues[5] estimating that 47% of the jobs in the United States are at risk of being replaced by machines within the next 10 to 20 years, which became a hot topic across the globe. A survey was also conducted in Japan using similar methods, and the results published in 2015 suggest that 49% of jobs are at risk of being replaced by machines.[6] A report published by the World Economic Forum in 2016 anticipates that based on questionnaire surveys conducted with 371 human resources officers of companies around the world, a total of 7.1 million jobs will be lost worldwide between 2015 and 2020, but there will be a total gain of 2 million new jobs.[7] Some say that "technological unemployment," which means that skill acquirement and worker migration cannot keep pace with the speed of technological innovation and that human jobs will be replaced by machines, has already become a reality.[8]

However, despite the concern that "human jobs will be replaced by machines," many now consider that not the entire jobs of domain experts but some of the "tasks" of such jobs will be replaced by AI and robotics, at least in the short term.[9]

Some note that instead of competing with machines, productivity would increase when humans, who have intuitions and creativity, collaborate with machines that are good at processing vast volumes of data and computing. For example, collaboration between AI and humans has created new pieces of artwork and strategies in the domain of art and design as well as in the world of *shōgi*

Technology)," 2017.3.31, < http://www.nedo.go.jp/content/100865202.pdf >; Cabinet Office, "Annual Report on the Japanese Economy and Public Finance 2017," 2017.7, chapter 3. < http://www5.cao.go.jp/keizai3/2017/0721wp-keizai/summary.html>

[5] Carl Benedikt Frey and Michael A. Osborne, *The Future of Employment: How susceptible are jobs to computerisation?* Oxford Martin Programme on Technology and Employment, 2013. <https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf>

[6] Nomura Research Institute et al., "Computerization and the Future of Jobs in Japan," 2015. <https://www.nri.com/~/media/PDF/jp/journal/2017/05/01J.pdf> (in Japanese).

[7] World Economic Forum, "The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution," 2016.1, p.13. <http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf>

[8] Erik Brynjolfsson and Andrew McAfee, *Race Against the Machine*, Lightning Source Inc, 2011.

[9] Documents pointing out the changes in "tasks" caused by AI include the following: World Economic Forum, *op.cit.*(4), p.19; James Manyika et al., *A future that works: automation, employment, and productivity*, McKinsey Global Institute, 2017, p.7. <https://www.mckinsey.com/~/media/McKinsey/Global%20Themes/Digital%20Disruption/Harnessing%20automation%20for%20a%20future%20that%20works/MGI-A-future-that-works_Full-report.ashx>; Noriyuki Yanagawa et al., "Advantages of humans and management in the era of AI," *NIRA Opinion Paper*, No.25, 2016.11. <http://www.nira.or.jp/pdf/opinion25.pdf> (in Japanese).

(Japanese chess).[10] There are tasks at which AI and robotics are better than humans, such as presenting possible outcomes by reading an enormous amount of data and academic papers or detecting diseases in agricultural crops and abnormal behaviors in humans.[11] Tasks that can be replaced by AI and robotics include tasks that we rather "want to be taken away"[12] owing to the high risk and heavy physical burden. However, there are tasks that can be technically replaced by machines but that require humans to handle and take ultimate responsibility from the perspective of human values, social systems, and laws, as in hospitality and diagnostic imaging in the domain of healthcare.[13] When introducing AI and robotics, it is necessary not only to consider the technological potentials but also to think of the elements of the tasks in experts' jobs in each domain and the manner in which they should be divided and assigned, in light of human values, social systems, and laws. Therefore, it is also a priority not just to cultivate human resources that develop AI and robot technologies but also to develop human resources that can utilize AI and robots in society or in business.[14]

2. Organizational culture and human values

In terms of labor, many routine tasks remain in Japan compared with other countries.[15] Some consider that "Japanese employment practices," which are characterized by lifetime employment, seniority-based pay systems, and an enterprise labor union system, would significantly change from the introduction and dissemination of AI and robotics.[16] For example, many more companies have introduced new forms of employment, such as telework, in recent years.[17] Some note that because AI and robotics facilitate autonomy and automation, they can cause frictions in an organizational culture such as military, which considers top-down command and control or hierarchy to be important.[18] Therefore, organizations must think about their culture, employment forms, and work styles when introducing technology, and they must try to establish an incentive framework by honoring people who are successfully using technology[19] or forming a community where people can share case examples.[20]

AI may increase job performance by compensating for a lack of experience; for example, knowledge, skills, and knowhow are stored in databases and visualized and shared in real time along

---

[10] See Part 2 "III Art and Design" and "Column 2 Japanese Chess (Shōgi)" of this report.
[11] See Part 2 "I Healthcare," "VII Agriculture," and "VIII Public order and Security" of this report.
[12] Dangerous tasks, such as pesticide spraying and mowing on slopes, are actively being replaced by machines. See Part 2 "VII Agriculture" of this report.
[13] See Part 2 "I Healthcare" and "V Hospitality" of this report.
[14] See Part 3 "VII Development and Recruitment of AI-related Human Resources" of this report.
[15] Sara De La Rica and Lucas Gortazar, "Differences in Job De-Routinization in OECD Countries: Evidence from PIAAC," *IZA Discussion Paper*, No.9736, 2016.2. <http://ftp.iza.org/dp9736.pdf> Japan is ranked fourth in terms of intensity of routine tasks among 22 countries surveyed.
[16] Conference toward AI Network Society, Institute for Information and Communications Policy, Ministry of Internal Affairs and Communications, "Report 2017 - Toward Promotion of International Discussions on AI Networking," 2017.7.28. Ministry of Internal Affairs and Communications Website < http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/Releases/Telecommunications/170728_05.html>
[17] See Part 3 "V Technological Innovation and Employment" of this report.
[18] See Part 2 "Column 1 AI applications for Defense and National Security Overseas " of this report.
[19] See Part 2 "About the Introduction and Use of 'Predictive Crime Defense System' in the Kyoto Prefectural Police Department" of this report.
[20] See Part 2 "VII Agriculture" of this report.

with the introduction and dissemination of AI, which may allow newcomers to grasp the statuses of animals and plants grown and raised in agriculture or may promote awareness in areas in which security measures must be implemented to prevent crimes.[21] With the expansion of the "democratization of AI,"[22] which means everyone can utilize AI technology, non-experts are now beginning to indirectly use the knowledge and skills of experts. For example, people can design logos or compose music by using AI in a short period of time inexpensively, even without knowledge and skills.[23] However, such changes may significantly affect not only the market but also social systems, laws, and human values. Therefore, social systems and laws must be established, while social, economic, and cultural values provided by the jobs of experts must be restructured.[24]

3. Infrastructure for utilizing AI and robotics: Data and human resources

To disseminate technology in society, it is important not just to develop technology itself but also to establish infrastructure to support it. To develop or use AI technology, vast volumes of data are necessary for learning. Therefore, standardization of data formats owned and used by organizations are necessary. In addition, data management methods to facilitate the cross-sectional use of data beyond institutions and organizations are required.[25] On the other hand, some note the necessity to address the protection of personal information and privacy, since anyone can be among those being controlled as an employee, client, or consumer through monitoring with the use of information and communication technology (ICT).[26] In addition, avoiding not to have any biases in AI learning data is essential.[27]

In addition to data, hardware for operating AI and robots, communication networks indispensable for data transmission, and general-purpose terminal devices, such as smartphones, which function as user interfaces, are also positioned as infrastructure. It is important for these elements to be provided at a reasonable price and for there to be ease of maintenance.[28] When establishing communication networks,[29] it is probably necessary to promote research on health risks

---

[21] See Part 2 "VII Agriculture" and "VII Public order and Security" of this report.

[22] "Google makes the use of AI easy, US IT businesses accelerate "democratization of IT, there are issues like data monopolies," *Nihon Keizai Shimbun*, 2018.1.18, p.13. (in Japanese)

[23] See Part 2 "III Art and Design" of this report.

[24] For example, Part 2 "III Art and Design" of this report explains that discussions on how to handle copyrights are being held. "V Hospitality" notes that if robots provide hospitality, workers will be free of "emotional labor," but they may have less opportunities to come into contact with the "gratitude" or "smiles" of customers.

[25] To make predictions and conduct a performance analysis, a certain volume of data must be accumulated. Part 2 "VII Agriculture" of this report notes that data can be obtained only in certain seasons in agriculture, and it takes time to accumulate data. "VIII Public Order and Security" also explains that the system cannot be used in areas in which the number of crimes is low, in terms of the "Predictive Crime Defense System" introduced by the Kyoto Prefectural Police Department.

[26] Part 3 "VI Human Resources and Labor Management by IT and its Regulation: Japan and Overseas" of this report describes what level of employee monitoring is permitted for the purpose of labor control. Part 2 "II Elderly Care" of this report explains the difficulty of determining where to draw the line between "elderly watching" and "monitoring" of those in need of care.

[27] For example, there are disputes over the credibility of data used in "crime prediction systems" being introduced in the domain of security. See Part 2 "VIII Public Order and Security" of this report.

[28] For example, there is seasonality in agriculture, and equipment must function without fail even if they are not used for several months. See Part 2 "VII Agriculture" of this report.

[29] Part 2 "VII Agriculture" of this report notes that it is necessary to secure a certain level of communication speed so that people can use systems in the cloud even in rural areas. "VIII Public Order and Security" explains that the presence of a secure network that extends to the Police station (Koban) level was a prerequisite for the introduction of

and similar issues posed by electromagnetic waves.[30]

When introducing AI and robotics, economic rationality and efficiency are emphasized, and therefore, the environments of the facilities, such as the structures and layouts, as well as people's work styles, are sometimes forced to adapt to AI and robots.[31] However, we must be careful not to steer or restrict behaviors and values of worker, customers, and consumers to achieve economic efficiency.

It is also important to cultivate human resources that can develop or utilize AI and robotics and to provide literacy education to employees.[32] To promote the use of AI and robotics in society and in business, it is also necessary to think about ethical, legal, and social implications (ELSI), including the issue of privacy and security measurement, as well as to cultivate experts who can serve as an intermediary between technology and society.[33]

Arisa EMA, The University of Tokyo

the "Predictive Crime Defense System" in the Kyoto Prefectural Police Department. In terms of autonomous driving, 5G (the fifth-generation mobile communication system) must be used so that vast volumes of data can be transmitted at high speed. "(Nickki's big question) What is next-generation communication "5G"?" 5G resolves delays of data and can be used for autonomous driving," Nihon Keizai Shimbun, 2017.9.25, Evening paper, p.2. (in Japanese).

[30] The World Health Organization (WHO) and International Agency for Research on Cancer (IARC) are debating the influence of electromagnetic waves coming from base stations and mobile devices on health. In Japan, the Ministry of Internal Affairs and Communications has a program for evaluating the safety of electrical waves. "Survey of the safety of electrical waves and evaluation technology," Ministry of Internal Affairs and Communications, Usage of electrical wave website. <http://www.tele.soumu.go.jp/j/sys/ele/index.htm> (in Japanese).

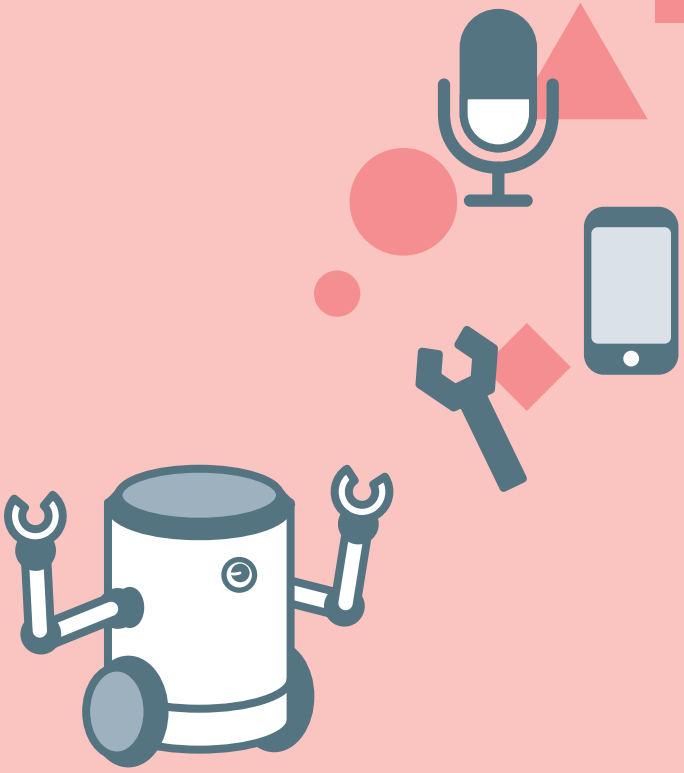
[31] Part 2 "V Hospitality" of this report describes how steps were eliminated and turned into slopes within a hotel such that robots can move around easily upon the introduction of robots. Part 2 "VII Agriculture" also introduces a study for making tree forms straight so that robots can easily harvest fruit.

[32] See Part 3 "VII Development and Recruitment of AI-related Human Resources" of this report. Part 3 "III AI and Employment Issues in France" and "IV AI, Robotics, and Labor in the Chinese Workplace" describe how governments provide support to ventures by using AI and note how they are committed to the cultivation of AI and IT human resources.

[33] Part 2 "II Elderly Care," "IV Education," "VI Transportation / Mobility," and "VIII Public Order and Security" of this report highlight issues of privacy and security as well as the need to set rules.

Part 1

Trends in Research and Technology



Part 1: Research and Technology Trends

[Overview]

Through the ongoing artificial intelligence (AI) boom, society's interest in information and communication technology (ICT) is increasing not only in fields driving the boom, such as machine learning, but also in a wide range of related technical fields that have not received keen attention in recent years. AI community has experiences cycles of "AI spring" and "AI winter." Caution is necessary over excessive expectations. It is said of not only ICT including AI but also new technology in general that technology responds to various needs in society while itself changing society, and giving rise to issues in tandem. It is preferable that society respond to these issues. In order that the AI boom not be a transient one, it is important to recognize that AI is developed and used in interaction with society.

Technologies related to AI are fragmented, and it is difficult to address them all. Therefore, Part 1 outlines the following nine research topis in three domains, (1) topics related to knowledge and data processing, (2) topics related to the boundary between human and machine, and (3) topics related to industry and daily life.

① Topics related to knowledge and data processing

In addition to the knowledge processing and machine learning technologies driving the current AI boom, natural language processing and image acquisition / recognition, which have shown remarkable development as a result of this boom, are described.

② Topics related to the human–machine boundary

Through the widespread application of AI and robotics, the importance of the conveyance of information between humans and machines is increasing. The speech interfaces responsible for this, and the human–agent interaction, which handle the interactions between machines and humans are described.

③ Topics related to lifestyle and industry

In addition to robot and IoT (internet of things), which continue to permeate into society, changing industry and daily life, multi-agent systems and crowdsourcing, which are the fundamental technologies for the design and operation of new social structures and systems, are described.

Notable social background, technological trends within Japan and overseas, real-world applications, and promising areas of application for each research topic are described, then the social issues that may arise in the future are presented.

I Knowledge Processing and Machine Learning

1. Historical Background

Looking back at the history[1] of artificial intelligence, several underlying technologies have been studied in each era.[2] In the 1960s, the task of expressing intellectual works by combining various items and how to effectively find a solution from among them (called the "search problem") was addressed as an issue central to AI research.[3] For example, when playing Shogi, from among the various combinations of moves, it is necessary to efficiently search for the move that leads to victory. The method of searching for this solution is called a "search" technique.[4] However, for example, when trying to consider combinations of moves in Shogi, the number of moves is enormous and searching is not straightforward.[5] Moreover, when translating, it is necessary not only to understand simple syntax combination operations but also to have knowledge of the field to be translated. Therefore, a new approach was seemingly required.[6]

Humans possess a variety of knowledge; by applying that knowledge, they can solve accurately and efficiently problems. For example, if you are a professional Shogi player, by applying knowledge of set moves, among others, you can narrow down prospective moves. In AI, the technology to use this kind of knowledge, known as "knowledge processing,"[7] attracted attention in the 1970s and research progressed.[8] This technology is widely used in infectious disease diagnosis systems (MYCIN)[9], and in

---

[1] At the Dartmouth conference held in the US in 1956, the academic field of artificial intelligence was established. "History of Artificial Intelligence" The Japan Society for Artificial Intelligence Website <http://www.ai-gakkai.or.jp/whatsai/AIhistory.html> (in Japanese)

* The date of last access for internet information in this paper is February 26th, 2018

[2] AI is defined as "cognitive machines, especially the science and technology to create cognitive computer programs." However, this definition varies between researchers, and because "cognition" and "intelligence" are not defined, defining artificial intelligence is still said to be difficult. "Artificial Intelligence FAQ" The Japan Society for Artificial Intelligence website <http://www.ai-gakkai.or.jp/whatsai/AIfaq.html> (in Japanese); Ministry of Internal Affairs and Communications "White Paper on Information Communications Heisei 28 Edition," 2016, pp. 233-234. <http://www.soumu.go.jp/johotsusintokei/whitepaper/ja/h28/pdf/n4200000.pdf> (in Japanese)

[3] "Assuming the source of intelligent expression to be in searching, and focused on the issue of efficient searching" The Japanese Society for Artificial Intelligence "Encyclopaedia of Artificial Intelligence," Kyoritsu Publishing 2017, pp. 5-6, Ishizuka Mitsuru et al. '"Foundations of Artificial Intelligence," Introduction' (in Japanese)

[4] As above, pp. 12-14. (Ishizuka et al. 'Search')

[5] This problem was called "combination explosion," which was a major problem in early AI research. In the UK in 1973, at the symposium of the Science Research Council (SRC), which was discussing government subsidies for scientific research, the lack of understanding of this issue was pointed out, and it was said that the British government had significantly reduced its AI research budget as a result. Stuart Russell and Peter Norvig "*Artificial Intelligence, A Modern Approach*" Second Edition, Prentice Hall, 2003, p. 22.

[6] As above, p. 21. In America, machine translation of cutting-edge science and technology papers between English and Russian was vigorously researched; however, the Automatic Language Processing Advisory Committee (ALPAC) of National Academy of Sciences reported in 1966 that "there is no prospect of immediate realisation," and hence, a new direction was being sought. (ALPAC, "Language and Machines: Computers in Translation and Linguistics," 1966, p. 24. <http://www.mt-archive.info/ALPAC-1966.pdf>)

[7] "Knowledge processing" is classified into fields of "knowledge expression," which discusses how to express knowledge, and "reasoning," which discusses how to use the expressed knowledge. Refer to "*Artificial Intelligence, A Modern Approach*" Second Edition" part 3, "Knowledge and Inference"

[8] The Japanese Society for Artificial Intelligence supra note (3), pp. 6-8, Ishizuka Mitsura et al. "*Foundations of Artificial Intelligence*," Introduction (in Japanese)

[9] Bruce G. Buchanan and Edward H. Shortliffe, *Rule Based Expert Systems: The MYCIN Experiments of the St anford Heuristic Programming Project*, Massachusetts: Addison-Wesley, 1984. <http://people.dbmi.columbia.edu/~ehs7001/Buchanan-Shortliffe-1984/MYCIN Book.htm>

systems for estimating the composition of organic compounds (DENDRAL)[10], and was a fundamental technology supporting the AI boom centering on expert systems[11] in the 1980s. In Japan too, expert systems were enthusiastically adopted in the steel industry, etc.[12] However, at the time, for the AI to use knowledge, a huge amount of manual effort was required[13], such as in investigating the knowledge in detail through interviews, and hence, knowledge processing technology was mainly limited to use in large-scale industrial fields.

From these circumstances, the technology required for AI to acquire knowledge by itself, namely "learning" technology, has come to be considered essential for AI.[14] The technology by which a machine automatically learns knowledge, called "machine learning" is a key technology supporting the current AI boom.

As described above, search, knowledge processing, and machine learning are fundamental technologies essential to AI today. Knowledge processing and machine learning, which have been developed remarkably in recent years, are explained below.

2. The State of Knowledge Processing

In the knowledge-processing technology of the 1980s, the methodology of knowledge-building was not yet established, and there were serious issues such as the reusability of knowledge,[15] but through later research, the current situation has significantly changed. Through the application of the concept of organization (ontology)[16] to describe various kinds of knowledge, the theory of knowledge construction was improved and the description and reuse of knowledge has become simple. Furthermore, through the spread of the internet and the popularity of open government and open data[17], even without creating knowledge independently, it has become possible to easily acquire knowledge from the internet.

Currently, a format called "Linked Data"[18] for enabling a computer to understand described knowledge has become popular, and various data are published in this format[19]. Using linked data, such as in association games, one can follow linked items and gather a large amount of related knowledge. For example, NHK trialed providing broadcast information as linked data.[20] In this trial,

---

[10] Robert K. Lindsay et al., "DENDRAL: A case study of the first expert system for scientific hypothesis form ation," *Artificial intelligence*, Vol. 61 No. 2, 1993.6, pp. 209-261. <https://deepblue.lib.umich.edu/bitstream/hand le/2027.42/30758/0000409.pdf>

[11] A system making similar judgments as experts by using knowledge

[12] Tsuchiya Shun et al. eds. "*AI Encyclopaedia Second Edition*", Kyoritsu Publishing, 2003, p. 11 (in Japanese)

[13] This problem is called the knowledge acquisition bottleneck. *The Japan Society for Artificial Intelligence* supra note (3) (Hiroshi Motoda et al. "*Machine Learning and Data Mining*" Introduction (in Japanese)

[14] As above

[15] Knowledge used in expert systems should be constructed at each facility of its use, and owing to inefficiency, it was necessary for each facility to share knowledge and reuse it. As above, p. 1256. Riichiro Mizoguchi "*Knowledge Engineering and Expert Systems*" (in Japanese)

[16] As above, pp. 1259-1260. Yoshinobu Kitamura "*Ontology and Schema*" (in Japanese)

[17] Open Government is an effort to open up the government to the public using the internet. In order to increase the transparency of administrative agencies, in Open Government, various data held by administrative agents are made public (Open Data). "What is Open Government?" OpenGovLabWebsite <http://openlabs.go.jp/whatis/>

[18] The Japanese Society for Artificial Intelligence *supra note* (3), pp. 1316-1318. Takeda Hideaki, "*Linked Open Data (LOD) Fundamentals*" (in Japanese)

[19] On the following website, one can check the status of published data. Andrejs Abele and John McCrae, "Th e Linking Open Data cloud diagram," *Insight Centre for Data Analytics website* <http://lod-cloud.net/>

[20] "NHK Linked Data API Service Information," NHK Broadcasting Technology Laboratory Website

it was possible to connect the region where the user is located to video related to that region, and it was possible to widely use the related information. In addition, Fujitsu Laboratories created a system that collects published link data and facilities, searching the data in aggregate.[21]

By collected linked data, it is possible to create knowledge databases. This kind of knowledge database is called a "knowledge graph."[22] A knowledge graph is a large volume of collected information showing links between, e.g., people, places, and things, and is essential to create question and answer systems for answering various questions and online search systems. For example, in IBM's case, a knowledge graph created from a free online encyclopedia (Wikipedia) is used in the company's AI system, "Watson;" this is a core technology in the system that allows it to answer questions in lieu of people.[23]

IT companies such as Google, Facebook, and Microsoft are creating their own knowledge graphs.[24] To further increase their scale, technology is necessary to automatically create accurate knowledge graphs, and is an important research theme among AI researchers.

3. The State of Machine Learning

Machine learning is one of the fields of research for realizing an AI with learning capabilities.[25] Humans, possessing the ability to learn, can acquire new knowledge. For example, a human child can, upon seeing a cat, being taught by their parents that "there's a cat," and learning that cats have characteristics such as ears, obtain the knowledge required for recognizing a cat upon seeing one the next time. AI is also expected to have the same capability through machine learning. Various machine learning frameworks have been considered; however, among them, "learning from example" is often used.[26] In other words, by providing examples to a machine, common characteristics are extracted from the data as knowledge. In recent years, with the development of the internet and improvement of large-scale databases, in addition to creating an environment in which enormous volumes of data can be easily used, developments in machine learning technology are also drawing attention.

One of these machine learning technologies is deep learning.[27] A learning technology called "Neural Networks," imitating the network of the countless number of neurons comprising the human brain, having been studied for many years, has been developed.[28] In deep learning, data features are learned by expressing the structure of layered hierarchies as a mathematical model, processing that

---

<https://www.nhk.or.jp/strl/ld/> (in Japanese) The service was offered for a limited time for research and investigation purposes

[21] "LOD4ALL." <https://lod4all.net/>

[22] "The following details the Knowledge Graphs announced by Google in 2012." *The Japanese Society for Artificial Intelligence* supra note(3), p. 1314. Takahiro Kawamura "*Metadata Usage*" (in Japanese)

[23] Jose Manuel Gomez-Perez et al., "Enterprise Knowledge Graph: An Introduction," Jeff Z. Pan et al., eds., *Exploiting Linked Data and Knowledge Graphs in Large Organisations*. Cham: Springer, 2017, p. 9.

[24] Heiko Paulheim, "Knowledge Graph Refinement: A Survey of Approaches and Evaluation Methods," *Semantic Web*, Vol.8 No.3, 2017, pp.489-508. <http://www.semantic-web-journal.net/system/files/swj1167.pdf>

[25] The Japanese Society of Artificial Intelligence *supra note* (3), p. 280. Hiroshi Motoda et al., "*Machine Learning and Data Mining*," Introduction (in Japanese)

[26] As above, pp. 281-283. Hiroshi Motoda et al., "*Machine Learning and Data Mining*," Introduction (in Japanese)

[27] As above, pp. 532-534. Hideki Aso, "*Deep Learning*" (in Japanese)

[28] "A method for learning by representing the mechanism by which signals are transmitted between neurones through a combination of simple mathematical expressions, and giving examples to this formula." See also Section 20.5 of Russell and Norvig *supra note (*5)

data as input in a certain layer, and repeatedly processing the output in other layers. In neural networks, up to now, learning could not be performed well when there were many layers (deep)[29]; however, in recent years, technology that can learn even when there are deep hierarchies has been developed[30] and has come to be used as deep learning.

In deep learning, by deepening the hierarchy, it becomes possible to hierarchically extract characteristics present in the data, and consequently, the accuracy of learning is improved.[31] For example, in conventional machine learning, for recognizing an image of a cat, humans must first provide characteristics to the machine—whether it has ears and hair, its color, among others. However, in deep learning, image data is provided to the machine. By extracting characteristics such as ears and hair at lower layers, and synthesizing these at higher layers, the machine can hierarchically extract these characteristics to recognize a cat.

The accuracy of deep learning can be improved if a large amount of data can be made available, and accuracy has improved particularly in the fields of image and voice recognition. Studies on deep learning are being advanced primarily by IT companies holding large amounts of data[32], particularly Google, Facebook, Microsoft etc., and its implementations in Japan are being advanced by companies such as Preferred Networks.

"Reinforcement Learning,"[33] which is another method of machine learning, has also gained traction in recent years. For example, if an animal receives a reward, such as being fed after performing a series of actions, the preference for that behavior is reinforced. Reinforcement learning is a learning method that emulates this mechanism. In recent years, by combining reinforcement learning with deep learning, more advanced learning has become possible. For example, Deep Mind, a subsidiary of Google, has developed an AI that is a stronger Go player than even the top human Go player by combining deep learning, reinforcement learning, and search technologies.[34]

4. Future Issues

At present, advanced AI technology cannot be realized using knowledge processing or machine learning alone, but practical AI technology can be realized by using the two complementarily.[35]

As knowledge processing uses human knowledge, it has the advantage in that humans can easily understand its mechanisms. When using AI technology for decision-making involving responsibility, this kind of technology is necessary because the decision-maker must understand the reason of the

---

29 "Called the vanishing gradient problem." The Japanese Society for Artificial Intelligence, supra note (3), pp. 521-522., Shinichi Asakawa "Recurrent Neural Networks"

30 As above, pp. 532-534. Hideki Aso "Deep Learning" (in Japanese)

31 In 2012, in a general object recognition contest to recognize what is depicted in an image, the significant improvements in accuracy obtained when deep learning was used gathered immense attention, and formed the basis for the deep learning boom today.

32 Companies have been enthusiastic to incorporate outcomes of researches held at universities so that Geoffrey Hinton, emeritus professor at the University of Toronto, who led the development of deep learning, and professor Yann LeCun of New York University have worked at Google and Facebook, respectively.

33 Russell and Norvig *supra note*(5), Chapter 21

34 David Silver et al., "Mastering the game of Go without human knowledge," *Nature*, Vol. 550, 2017.10.19, pp. 354-359.

35 Simple tasks such as recognising an object in an image can be performed by a single AI technology alone; however, when performing complex tasks, such as those performed by IBM's Watson or Deepmind's Go AI, in many cases, multiple AI technologies are combined.

decision. In addition, in knowledge processing, it is possible to explicitly reflect the intent of a human in the AI, and design in advance the handling of special cases not present in the data. For example, in rare events such as disasters, data cannot be obtained in advance; however, by incorporating human knowledge, it is possible to implement responses to such events in an AI. However, as it can be difficult to create and acquire knowledge depending on the field, further technological development is required.[36]

Machine learning has an advantage in that it can automatically construct knowledge where there is a large volume of data. Therefore, where an abundance of data is obtained, it is possible for it to make decisions with a degree of accuracy surpassing human judgment. However, the use of technologies such as deep learning causes difficulties in explaining the reasoning behind the decision-making.[37] Moreover, it is difficult to apply machine learning appropriately to fields where there is scant data or in fields where data is not comprehensively collected, and further technological development is necessary to respond to these issues.[38]

Although some issues remain in current AI technology, its underlying technologies including knowledge processing and machine learning continue to mature, and it is becoming possible to implement advanced AI through the complementary use of these underlying technologies. In the future, it is also necessary to consider architectures to integrate these fundamental technologies.

Ryutaro Ichise, National Institute of Informatics

II Natural Language Processing

Languages used by humans on a daily basis, in contrast to artificial languages such as programming languages, are called "natural languages." This chapter describes the social background surrounding natural language processing technology as of February 2018, its state both domestically and overseas, promising areas of application, and future issues.

1. Notable Social Background

With the spread of web searches in the latter half of the 1990s, the utility of applications to process and search large-scale data using natural language gained wide recognition. Web searches are systems

[36] "Research and development of next-generation artificial intelligence technology capable of mutual understanding with humans," carried out by the National Institute of Advanced Industrial Science and Technology's Artificial Intelligence Research Centre (ARIC), wherein research and development of AI that can obtain knowledge understandable to humans from large amounts of inexplicit data is progressing. "NEDO-commissioned project, "Next Generation Artificial Intelligence/ Core Robot Technology Development / Research and Development of Next-Generation Artificial Intelligence Technology Fields / Research and Development of Next-Generation Artificial Intelligence Technology Capable of Mutual Understanding with Humans" National Institute of Advanced Industrial Science and Technology Artificial Intelligence Research Centre website <http://www.airc.aist.go.jp/nedoproject/index.html> (in Japanese)

[37] "There are sceptical views on the application of deep learning in areas requiring explanations based on scientific evidence such as healthcare." *The Japanese Society for Artificial Intelligence* supra note (3), pp. 1405-1406. Hiroshi Nakajima *"Applications of AI to Health Care Equipment"* (in Japanese)

[38] The RIKEN Innovation Centre's Advanced Intelligence Project (AIP) is conducting studies on the fundamental research and technology of new algorithms able to learn accurately from small amounts of data. *Artificial Intelligence Technology Strategy Conference* "Artificial Intelligence Technology Strategy," 2017.3.31, p. 2 *New Energy and Industrial Technology Development Organisation* website <http://www.nedo.go.jp/content/100862413.pdf> (in Japanese)

in which words are input and corresponding webpages are returned. This followed as an extension of full-text searches by searching for matching words (pattern matching), and it was believed that a deep understanding of the input words was unnecessary. However, in 2011, IBM's AI system (Watson) demonstrated performance surpassing that of a human quiz champion in a question answering task,[39] returning knowledge relevant to an input question and becoming a topic of conversation. It came to be recognized that, regardless of the field,[40] it had the ability to understand natural language comparable to humans.

Since 2012, technological innovation centering on deep learning has also been applied to natural language processing, thus changing research in the field dramatically between 2014 and 2015. Subsequently, research and development using deep learning has flourished. Deep learning-based natural language generation outputs fluent text to such an extent that it can scarcely be distinguished from human-written text. Deep learning has brought about a technological breakthrough,[41]achieving drastic improvements in language generation tasks such as machine translation, dialog, and document summarization.

2. Technology Trends

State-of-the-art research and development of natural language processing is being performed in the United States. Companies, universities, and institutions conducting research and development of natural language processing are particularly concentrated in the Bay Area on the West Coast and New York on the East Coast. Characteristic of research and development in America, IT companies typified by Google and Facebook are taking the initiative in the development of natural language processing. Research on information extraction and machine translation began with ACE (Automatic Content Extraction) led by the National Institute of Standards and Technology (NIST) under the Ministry of Commerce, and subsequently, DARPA (Defense Advanced Research Projects Agency) invested a significant amount of national defense expenditure through the GALE (Global Autonomous Language Exploitation), TIDES (Translingual Information Detection, Extraction and Summarization), and BOLT (Broad Operational Language Translation) projects.[42] In universities, military technologies are also being put into use for public benefit. For example, two researchers who founded the company Language Weaver[43] with machine translation technology developed in the above DARPA projects at its core were faculty members at the University of Southern California.

China is carrying out state-led research. In 2016, AI-related technological development was

[39] "Computer Wins on 'Jeopardy!': Trivial, It's Not" The New York Times < https://www.nytimes.com/2011/02/17/science/17jeopardy-watson.html >

[40] Supervised by Mamoru Komachi authors Yoh Okuno et al., "*Basics and Techniques of Natural Language Processing*," Shoeisha, 2016, pp. 14-25 (in Japanese)

[41] Yuta Tsuboi et al., "*Natural Language Processing Using Deep Learning*" (Machine Learning Professional Series) Kodansha, 2017, pp. 122-158 (in Japanese)

[42] "Collaborations> Past Projects." Linguistic Data Consortium Website <https://www.ldc.upenn.edu/collaborations/past-projects>; "BOLT (Broad Operational Language Translation)" Website <https://www.darpa.mil/program/broad-operational-language-translation>; Japan Science and Technology Agency R&D Strategy Centre, Systems and Information Science and Technology Unit, "Research and development outlook report, Systems and Information Science and Technology Field (2017)" Japan Science and Technology Agency R&D Strategy Centre, 2017, p. 231 <https://www.jst.go.jp/crds/pdf/2016/FR/CRDS-FY2016-FR-04.pdf> (in Japanese)

[43] Acquired in 2010 by SDL, which has the top market share for translation globally

headed by Tsinghua University, the Harbin Institute of Technology, and other research institutions such as the Chinese Academy of Sciences, and it is reported that 100 billion Chinese yuan (approximately 1.7 trillion Japanese yen)[44] will be invested over the next three years.[45] Moreover, research and development of natural language processing is also flourishing through IT companies. Both Tencent (腾讯) and Baidu (百度) have research and development sites in the US and have achieved numerous world-leading research results. There is a growing sense of an international community in natural language processing.

Conversely, in Japan, natural language processing has mainly been developed by companies; however, the environment has been changing drastically in the past decade. Until the 1990s, mainstream development originated from manufacturing companies, and research and development of natural language processing came to a brief halt with the collapse of the economic bubble. However, in the early 2000s, with the spread of the internet, the demand for web-related companies increased. Since the advent of deep learning, AI development startups from universities such as Preferred Networks and PKSHA Technology have become active, and these startups have drawn an influx of talent from universities and large corporations. Moreover, the government is carrying out AI research through the National Institute of Advanced Industrial Science and Technology (Artificial Intelligence Research Centre), the National Institute of Information and Communications Technology (Universal Communications Research Centre), and RIKEN (Innovative Intelligence Integration Research Centre), and is reported to be investing approximately 100 billion yen over ten years starting from 2016 (Heisei 28).[46]

3. Real-world Applications

Natural language processing technology has already been used in various situations such as Japanese language input, web searches, and spam filters, and is one of the technologies supporting the information society. The language generation field is predicted to achieve giant leaps in development within the next ten years, specifically in applications that output text, such as machine translation, dialog, and document summarization. In these applications, as fluent language output seems to have been attained through the arrival of deep learning, it appears that some of the roles that have so far been performed by people will be automated.

On the one hand, machine translation using deep learning can output fluently, but on the other hand, it does not always correctly reflect the intent of the original sentence, and close proofing by a human is essential. For example, translations involving deep understanding of the contents, such as literary translation, cannot be substituted by machine translation. However, in industrial translations, quality of that extent is not required for technical literature and medical domain, which constitute a large part of the translation market, and widespread adoption of machine translation is expected. In

[44] 1 Chinese yuan was converted as 17 Japanese yen (The official rate reported in December 2017)

[45] "China unveils three-year program for artificial intelligence growth," *China Daily*, 2016.5.24. <http://www.chinadaily.com.cn/business/tech/2016-05/24/content_25442308.htm>

[46] "Strategic Organisation through Artificial Intelligence 3 Agencies' Collaboration, Accelerating Business and Research" Nihon Keizai Shinbun, 2016.2.27, evening edition, p. 1 (in Japanese)

the future, the necessity for humans to take charge of the entire translation will hold for only some fields.[47]

Another application currently gathering significant attention is dialog.[48] In the fields of FinTech (financial services using IT), LegalTech (legal services using IT), e-commerce etc., humans with specialist knowledge have performed customer support tasks so far. In these fields, it is believed that systems that automatically generate responses to customers will become popular as part of support work. Such systems have already become widespread first in the US and Western Europe, but in Japan, an emphasis on the quality of support has meant that adoption has not progressed. In the future, however, even in Japan, the proportion of generations with no resistance to the use of information communications devices will increase, and these generations will become able to not only understand the difference in quality from human responses, but also master the use of these systems, and substitution for these systems is expected to advance.

Moreover, a promising area for the application of natural language processing is the support provided to people with disabilities. So far, voice recognition and speech synthesis technologies have been studied, and have even been loaded on Macs and iPhones to support those with hearing and speech impairments. However, since 2015, the fusion of language and image areas has been studied enthusiastically and methods for attaching captions to images and videos (text description) have been proposed. By combining caption generation for images and video with voice synthesis, visually impaired people can understand image contents. The combination of image, voice, and language processing technologies contributes to the realization of a world in which anyone can access information.

4. Future Issues

As research on language generation becomes more popular, issues of copyright and privacy with regard to generated sentences are likely to manifest, and how to respond to these is a further issue.[49] Ethical issues—for example, the handling of personal information in medical information processing, issues related to being able to delete past information from the internet (the right to be forgotten), and the issue of bias toward minorities on the basis of gender, race, etc.—are being discussed.[50] In Japan, The Japan Society for Artificial Intelligence launched an ethics committee in 2014 (Heisei 26).[51]

From the technology perspective, prior to deep learning, language creation rules and reference dictionaries were used to produce descriptions in a human-readable form, and hence, it was possible, to a certain extent, to prevent inappropriate language generation; however, when deep learning is used, control over the output is technically difficult. Until this is resolved in future research, it should

---

[47] Yuta Tsuboi et al., *supra note* (41) (in Japanese)

[48] Supervised by Mamoru Komachi, authors Yoh Okuno et al., supra note (40), pp. 212-236. (in Japanese)

[49] Koji Okumura "Content Created by Artificial Intelligence and Copyright - Focusing on Copyright Works" *Patents*., Vol. 70, No. 2, 2017, pp. 10-19, <https://system.jpaa.or.jp/patent/viewPdf/2742> (in Japanese)

[50] In machine learning, if there are many ethically problematic expressions concerning minorities included among the data used for learning, there will be problems of the AI using those expressions from which it learned.

[51] Yutaka Matsuo et al., "Efforts of the Artificial Intelligence Society Ethics Committee" "Artificial Intelligence," Vol. 30 No. 3, 2015.5, pp. 358-364 (in Japanese)

be used with a careful understanding of the utility and risks of high-accuracy language generation.

Mamoru Komachi, Tokyo Metropolitan University

Ⅲ Image Acquisition and Recognition

1. Overview of Image Acquisition and Recognition

The progress of AI technology in recent years has brought significant reforms centering on industry, and has also had profound effects on the field of image recognition and processing. As technical background, in addition to high-accuracy cameras and the miniaturization and cost reduction of various cameras, machine learning and recognition technologies such as deep learning have been developed. As social background, through the spread of smartphones, cloud computing,[52] and social media, images can be shared simply, and consequently, the targets and needs of image recognition have expanded. In other words, everyone can easily obtain images, and those images can be shared on social media, and image recognition needs—for example, recognizing people or objects and identification of people—can be said to have increased. This chapter describes the progress of image sensors playing the role of "eyes" in obtaining images, and image recognition and processing playing the role of the "brain" in interpreting these images.

2. Image Sensor Development

An image sensor is an element that converts light in the physical world to digital formats, and Japan has contributed significantly to its development. Image sensors developed by Japanese manufacturers remain competitive even today. Although image sensors are parts that correspond to eyes in people, by capturing information that humans cannot see, they can be applied to various purposes. While they have been used so far in specialist manufacturing and military applications, through cost reductions associated with mass production, high-capability image sensors are also being introduced in devices for general consumers.

（1） Color Image Sensors

Color image sensors capture red, green, and blue light in the same manner as human eyes, and over the past 10 years, their resolution has improved by 5–7×; even the resolution of the cameras used in smartphones can exceed 10 megapixels.[53] Further improvements in resolution are limited by storage capacity issues and lens performance (definition). As an alternative, development of high-dynamic-range compatible elements that can capture lighter and darker regions is advancing.

---

[52] Refer to Section 1 (2) Improvement of Infrastructure Environment of Chapter VII, IoT

[53] For example, the number of pixels in the rear-mounted sensor on the first-generation iPhone (released June 2 007) was 2,000,000 (2 megapixels), but in the latest model (released November 2017), that number is 12,000, 000 (12 megapixels). "Guides and Sample Code: iOS Device Compatibility Reference: Cameras." Apple Deve loper Website <https://developer.apple.com/library/content/documentation/DeviceInformation/Reference/iOSDeviceC ompatibility/Cameras/Cameras.html> (in Japanese)

（2） Multispectral Image Sensor (infrared sensor)

If an infrared sensor, which captures infrared light, is used in lieu of a color sensor, the reflection of light is suppressed, and facial recognition performance is improved. It also has the advantage that authentication can be performed using eye luster, and the popularity of this sensor is growing.[54] These sensors have so far been limited to use in night-vision equipment, but are now being incorporated into personal computers (PCs) and smartphones with the spread of facial authentication.

（3） Distance Image Sensors

The range image sensor is a device for measuring depth information around the camera, and it can be used to improve the performance of image recognition and automatic operation. In 2009, Microsoft released a piece of video game equipment equipped with a range image sensor called the "Kinect," which rapidly dropped in price and has been popular.[55] Moreover, in vehicles with driving support functions such as automatic braking, range image sensors are indispensable for determining the distance between the car and objects.

Range image sensors can be divided into several types according to their measurement method. There are those that use two image sensors, and those that use one image sensor combined with infrared radiation. They measure using the infrared light emission and its reflection, and each has its advantages and drawbacks depending on the measurement distance, application environment etc. (light/dark, weather). In the future, methods of combining multiple sensors will also be studied.[56]

（4） Light-field Cameras

Light-field cameras record not only light, dark, and color, but also information on the incident angle of light and include three-dimensional data. A micro lens array is installed on the front face of the image sensor (numerous microscopic lenses arranged together), recording not only the light/darkness of rays of light but also the incident angle information of the light ray.

Unlike conventional cameras, which record only two-dimensional information of brightness and color, the focal position (focus) of the image can be moved after capturing the image, and the depth of field (the in-focus region) can be changed. Thus, these cameras open up new possibilities. While there are drawbacks such as insufficient resolution and requirement of a large amount of light, practical applications such as the American company Lytro's launch to the public are being attempted.[57]

（5） Omnidirectional Cameras

In recent years, omnidirectional cameras are gathering attention owing to the spread of virtual reality (VR) technology; they can capture all-round images across 360° degrees. Products aimed at

---

[54] "Iris / Facial Authentication Optical Sensor Market, 24% CAGR growth 2017-2025" 2017.3.13. LEDs Magazine Japan website <http://ex-press.jp/ledj/ledj-news/ledj-biz-market/17594/> (in Japanese)

[55] "As understood from patent analysis, dominating by volume the strongest company in distance imagery, Microsoft has a decisive lead," Nikkei Electronics No. 1135, 2014.5.26, pp. 49-57. (in Japanese)

[56] "What combination of components is best for automatic operation? DENSO Technical Development Briefing Session," 2016.8.10, Response website <https://response.jp/article/2016/08/10/279956.html> (in Japanese)

[57] Lytro website <https://support.lytro.com/hc >

consumers are being sold both in Japan and overseas.[58] The omnidirectional camera was developed by applying earlier technologies combining multiple components and utilizing fish-eye lenses that can capture wide angles; however, as it is possible to capture images using these cameras in ways different from conventional cameras and as they offer a high degree of affinity to VR content,[59] their demand is increasing worldwide.[60]

(6) Wearable Cameras

As cameras become smaller and less expensive, wearable cameras worn on one's person have been developed with the aim of recording everyday activity. Among wearable cameras, first-person sensors that record the same images as the wearer's gaze are expected to be used in content production in sports, policing, data collection, and identification of criminals.[61] Moreover, there are also cameras on the market that are attached to glasses, allowing the shutter to operate with a wink.[62]

3. Progress of Image Recognition Research

Image recognition research has undergone rapid development in the past 10 years, especially in the past five years with the progress of research on deep learning. Research and development trends in the various fields of application of image recognition are explained as follows.

(1) General Object Recognition

General object recognition is a technique for sensing and recognizing where people and objects are present in a photographed image. Circa 2007, by understanding local features in images, and adopting a technique called "bag of features"[63] to differentiate images based on their composition, its performance improved. Moreover, thanks to the accumulation of sample image data necessary for learning in this method,[64] competitive development has progressed worldwide.

Furthermore, through the adoption of deep learning "convolution neural networks"[65] in image recognition from 2012,[66] the accuracy of image recognition has improved drastically. This method

---

58 RICHO THETA website <https://theta360.com/en/>; "SP360 Action Camera." Kodak Digital Cameras Website < https://kodakpixpro.com/Americas/cameras/actioncam/sp360/ >

59 For example, Toppan Printing produces VR content such as Azuchi Castle and Yomeimon at Nikko Toshogu Shrine. "Main Toppan VR Products" Toppan VR Digital Archive website <http://www.toppan-vr.jp/bunka/action.shtml> (in Japanese); "Next Generation Technical Features, AR developments, Excitement in Five Senses, Relief Printing, Tourist Spot Experiences," Nikkei Business Daily 2017.11.27, p. 10 (in Japanese)

60 "360° Cameras, Hot Competition" Nikkei Business Daily 2016.10.31, p. 7. (in Japanese)

61 "Panasonic develops wearable cameras for police around the world to combat terror" Nihon Keizai Shinbun, 2016.1.5, p. 12. (in Japanese)

62 E.g., Blincam Website <https://www.blincam.co/>

63 Gabriella Csurka et al., "Visual categorization with bags of keypoints," *Proceeding of Workshop on Statistical Learning in Computer Vision*, *8th European Conference on Computer Vision (ECCV)*, 2004. <http://www.europe.naverlabs.com/content/download/23625/171397/version/1/file/2004_010.pdf>

64 The PASCAL Visual Object Classes Website <http://host.robots.ox.ac.uk/pascal/VOC/> Implemented with funds received from the EU. "Pattern Analysis, Statistical Modelling and Computational Learning 2," European Commission CORDIS Website <http://cordis.europa.eu/project/rcn/85729_en.html>

65 A method for processing by integrating (convolution) data obtained by dividing an image so that image recognition can be performed regardless of the position of the identified portion.

66 Alex Krizhevsky et al., "ImageNet Classification with Deep Convolutional Neural Networks," *Proceedings of the 25th International Conference on Neural Information Processing Systems*, Vol. 1, 2012, pp. 1097-1105. <https://papers.nips.cc/paper/4824-imagenet-classification-with-deep-convolutional-neural-networks.pdf>

is also applied to object recognition—for example, the identification of plant and animal species—and the race for development continues.

(2) Facial Recognition

There is immense variety among faces; however, they have partially common characteristics. Focusing on these common characteristics, a method of high-speed facial identification was conceived in 2000,[67] and facial recognition capabilities began to be incorporated into digital cameras.

Deep learning has also applied to this field in recent years, and it has become possible to recognize not only faces, but also sex, age, facial expression, and various other attributes. Furthermore, facial recognition technology, which can identify an individual from their face, has also been developed, and has begun to be applied in immigration control and the identification of suspicious individuals.[68] Technology to identify individuals from their faces is expected to be applied to a variety of purposes; however, this raises privacy concerns described later.

(3) Medical Applications

In the medical field, doctors identify lesions from X-ray, CT, and MRI images, and research on the application of image recognition to this field is advancing.[69] For example, it is supposed that candidate regions with abnormalities can be detected using deep learning technology, and doctors can make a final decision on them.

4. Future Issues

Image recognition has been developed rapidly in recent years; however, it has simultaneously given rise to social and ethical problems, which may affect its widespread application.

(1) Use of Data for Deep learning

Deep learning has led to significant developments in image recognition, but has also brought about technological limitations and social issues. In image recognition using deep learning, performance can be improved by learning from larger image sample sets, but there are limits to the number of image samples that can be used. Some internet companies collect personal image data from the internet and are using them in machine learning cases. However, legal concerns such as copyright and privacy, and ethical concerns regarding the use of data created or published by individuals are being raised for machine learning.[70]

---

[67] The detection speed was increased in evaluating parts of an image that are not a face by using a simple calculation to quickly determine whether or not it was a face. Paul Viola and Michael J. Jones, "Robust Real-Time Face Detection," *International Journal of Computer Vision*, Vol. 57 No. 2, 2004.5, pp. 137-154.

[68] "High Accuracy Facial Authentication Software by Panasonic using Deep Learning" Nikkei Business Daily 2018.2.22, p. 4 (in Japanese); "Facial Authentication, Evaluation in 10 seconds, Ministry of Justice, and launched at Haneda Airport, Improving Immigration Efficiency for Japanese" Nikkei Business Daily, 2017.10.14, p. 38 (in Japanese); "In anticipation of 2020 the Tokyo Marathon takes measures against the heat" Sankei Shimbun 2018.2.26, p. 30 (in Japanese)

[69] "The current status and outlook for the use of AI in diagnostic imaging" 2017.6.29. MedTec Japan website <http://www.medtecjapan.com/ja/news/2017/06/29/1936> (in Japanese)

[70] Asakawa Naoki, "Can you use data gathered online for AI learning?" 2017.6.22. Nikkei CrossTech website <http://tech.nikkeibp.co.jp/it/atcl/column/17/051800199/062000008/> (in Japanese)

(2) Use of Image Recognition Cameras

As cameras are mounted on various devices and as the accuracy of image recognition is improved, privacy issues will also arise. As images from which individuals can be identified correspond to personal information, considerations such as the observance of the "Law concerning the protection of personal information" (Law number 57 of Heisei 15 (2003)) and giving advance notice of use are required.[71]

Specific examples of privacy and ethical issues are as follows. A small camera is incorporated into the eyewear-type mobile device built by Google, "Google Glass."[72] From a privacy perspective, Google decided not to use facial recognition technology capable of identifying individuals for the time being;[73] nonetheless, owing to concerns around covert filming etc., sales to individuals were halted.[74] Moreover, issues of racial discrimination from the use of deep learning in image recognition have also arisen.[75]

(3) Issues Surrounding Application to Medical Fields

Image recognition in the medical field, in addition to assisting the identification of lesions as above, is also expected to include the use of wearable cameras to capture and analyze images during communication with patients and in medical treatment applications (for example, the psychiatric field).[76]

However, when applied to the medical field, it is assumed that concerns about errors, missed lesions, misdiagnoses, privacy etc., will arise, and with the widespread application of image recognition technologies in these fields, response to these issues is necessary.

Atsushi Nakazawa, Kyoto University

IV Speech Interfaces

1. Notable Social Background

A speech interface is a system in which a person can interact with a computer using their voice. In general, this includes both when speech is used as computer input (where a human voice is processed by the system) and when it is used as output from the system (where the voice output by the system is heard by a person); however, the focus in this chapter is the former—the handling of

[71] IoT Development Consortium et al. "Camera Image Usage Guidebook" 2017.1, pp. 16-20. METI website <http://www.meti.go.jp/press/2016/01/20170131002/20170131002-1.pdf> (in Japanese)

[72] Thad Starner, "Project Glass: An Extension of the Self," *IEEE Pervasive Computing*, Vol. 12 No. 2, 2013.4, pp. 14-16.

[73] "Google announced that the Google Glass facial recognition application will not be certified for the time being," 2013.6.1. ITmedia NEWS website <http://www.itmedia.co.jp/news/articles/1306/01/news012.html> (in Japanese)

[74] "Privacy halts Google's Glass Device, ceases sales to individuals" Nikkei Keizai Shimbun 2015.1.17, p. 13 (in Japanese).

[75] Jana Kasperkevic, "Google says sorry for racist auto-tag in photo app," 2015.7.1. Guardian Website <https://www.theguardian.com/technology/2015/jul/01/google-sorry-racist-auto-tag-photo-app>; "Gorillas and faulty image recognition, Google apologises" Asahi Shimbun, 2015.7.3, p. 11 (in Japanese).

[76] "Special Feature: Prescriptions for Communication," Sogo Shinryo, Vol. 27 No. 5, 2017.5, pp. 568-623 (in Japanese).

speech recognition.

(1) Development of Speech Recognition Technology

Speech recognition is a process of considering voice signals in human speech as input, and outputting a corresponding character or word string. Speech recognition research has been undertaken for a long time, and in Japan, research has been ongoing as a field of pattern recognition[77] since the 1960s.[78]

Until the 1990s, this was limited to experiments inside laboratories, but with the widespread usage of computers, around 2000, IBM developed the speech recognition software "ViaVoice" targeting general users, and also sold a Japanese language version.[79] Being able to recognize human speech became a hot topic, and it even appeared in TV commercials, but did not achieve widespread use. The reasons for this are that, prior to its use, it was necessary for each user to record themselves speaking several hundred sentences,[80] called enrolment, in addition to limitations in recognition performance and the size of recognizable vocabulary. In any case, the technology at the time had not been developed sufficiently for practical use. In addition, at that time, desktop PCs, which were difficult to carry around, were popular, and the situations where these PCs could be used to perform speech recognition may also have been a limiting factor.

(2) Arrival of Applications for General Users

From the second half of the 2000s through to the 2010s, through improvements in communication speeds, the development paradigm changed dramatically[81] through the advent of cloud-based speech recognition based on cloud computing.[82] Until then, speech recognition processing was performed on the user's computer; however, in cloud-based speech recognition, speech recognition is performed on a server by sending speech data to that server. The advantages of operating in this way are profound. Users can effortlessly use speech recognition from existing voice devices (e.g., smartphones). Moreover, as the dictionary used for speech recognition is also stored in the server, it is possible for system developers to update it at any time. Furthermore, as speech data is sent to the server, data collection becomes extremely easy, and the collected data can be used for performance improvement through machine learning.

---

[77] The recognition of which predefined classes input patterns of characters or sounds belong to (e.g., what alphabet character a set of line drawings represents)

[78] Toshiyuki Sakai and Shuji Doshita, "An Automatic Recognition System of Speech Sounds," *Studia phonologi ca*, Vol. 2, 1962, pp. 83-95. <http://hdl.handle.net/2433/52632>

[79] "ViaVoice millennium speech recognition software latest version, improvements to recognition accuracy and e ase of use (in Japanese)" 1999.9.28. IBM website <http://www-06.ibm.com/jp/press/1999/09287.html>

[80] "IBM Japan announces "ViaVoice 8" with reduced recognition errors (in Japanese)" 2000.9.21. ITmedia webs ite <http://www.itmedia.co.jp/news/0009/21/viavoice.html>

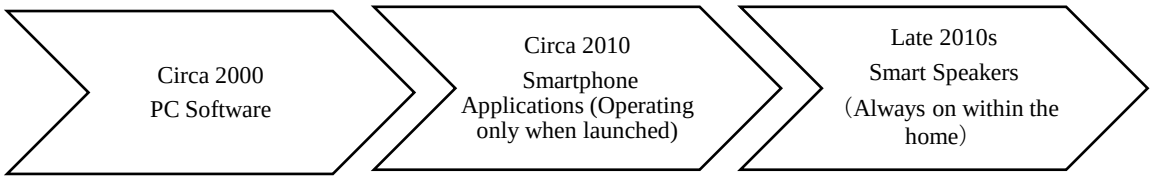
[81] "Market Trends Edition: Leaps using the Cloud, Applications Expanding beyond Smartphones (in Japanese)," Nikkei Electronics, No. 1098, 2012.12.24, pp. 26-33.

[82] Refer to 1 (2), "Improvement of Infrastructure Environment" of Chapter VII, IoT

From the paradigm shift above, speech recognition applications targeting general users that can be used on their smartphones appeared. Google's "Voice Search"[83] and Apple's "Siri"[84] are typical examples. These applications perform more than just speech recognition; they can perform web searches or respond to questions using the results of speech recognition. In addition, these applications are both free to use, and the aim of the application development is not sales, but an up-front investment based on a long-term vision—display of the companies' technical prowess, collection of customer data including voice, and introduction to the company's other services.[85] Prior to the voice search, Google had been pursuing data collection through the "GOOG-411" telephone directory assistance service.[86]

In recent years (from the latter half of the 2010s), household electronics appliances called "smart speakers" have been introduced, making it possible to listen to music and news and control home appliances through voice operations by connecting to the internet. In Japan, sales of Google's "Google Home"[87] and Line's "Clova WAVE"[88] began in October 2017, and of Amazon's "Amazon Echo"[89] in November 2017.

Figure 1. Changes in the state of application of speech interfaces



(Source) Created by the author(s)

2. Technology Trends

In 1990, the technology used in speech recognition was primarily machine learning based on statistical methods; however, in recent years, the technology has proceeded to that using deep learning, which has dominated the field.[90] In the speech recognition field, there is the clear criterion for the speech recognition accuracy (the ratio of correct words among all recognition results), and shared speech databases are also being constructed, whereby if a superior method is found, it tends to spread at once, both domestically and overseas. In other words, speech recognition performance improves as the amount of training data increases and these data (real data) are obtained from an

[83] Published in the 2009 Japanese Language Edition. "Japanese-language version of Google Voice-Search launched, accessible from iPhone and Android (in Japanese)" 2009.12.7, InternetWatch website <https://internet.watch.impress.co.jp/docs/news/333996.html>

[84] Published in the 2012 Japanese-language edition. "Apple releases the iOS 5.1 update, iPhone 4S supports Siri in Japanese (in Japanese)," 2012.3.8. ITpro website <http://itpro.nikkeibp.co.jp/pc/article/news/20120308/1043362/>

[85] Kobayashi Masakazu "From the Cloud to AI, the next battlefield for Apple, Google and Facebook (in Japanese)," Asahi Shimbun, Asahi Shimbun Publishing, 2013, pp. 115-118

[86] "Google launches 411-Service," 2007.4.7 TechCrunch Japan website < https://techcrunch.com/2007/04/06/google-launches-free-411-business/> This service was closed in November 2010.

[87] "Google Home" Google website <https://store.google.com/product/google_home>

[88] "Clova WAVE" (in Japanese) LINE website <https://clova.line.me/>

[89] "Amazon launches "Echo" AI speaker at ¥11,980 (in Japanese)" Nikkei Sangyo Shinbun, 2017.11.9, p. 2

[90] Tatsuya Kawahara, "Development of Speech Recognition Technology (in Japanese)," IEICE Tech.,PRMU2015-111, 2015.12, pp. 111-116. refer to <http://sap.ist.i.kyoto-u.ac.jp/members/kawahara/paper/KAW-prmu15-12.pdf>

environment close to practical use (namely, actual users). Therefore, performance improvement accelerates where the positive spiral "user usage -> data collection -> performance improvement -> user usage" begins.

In deep learning, a much larger amount of data and computational resources are required than in conventional methods, and hence, speech recognition research and development seems in practice to be limited to companies having large-scale data and computational resources (Google, Apple, Amazon, Microsoft, etc.). In Japan, speech recognition research has been carried out in universities and laboratories of enterprises (NTT, IBM Japan, Hitachi, Toshiba, NEC, etc.); however, research is believed to be shifting more toward areas of application rather than speech recognition accuracy itself. For example, in the speech interface field, which is one of the applications of speech recognition, NTT DoCoMo's "Shabette Concier"[91] and Yahoo's "Voice Assist"[92] applications, which allow one to set alarms and make phone calls simply by speaking to one's smartphone have been released, as well as a multitude of startups providing similar services (Inago, etc.). [93]

In the US, Amazon launched the "Alexa Prize"[94] development contest in 2016, with companies sharing their real data and involving the academic communities such as universities of each country, which is a trend of advancing technological development in this manner. This is not a short-term trend with the aim of collecting on an investment, but rather is viewed as an up-front investment based on a long-term vision. Moreover, research on technically difficult issues makes high demands for real data, and as it is difficult for academia to collect large amount of real data, it can be said that these efforts are an ideal form of industry–academia collaboration. This kind of effort rooted in long-term vision is seldom observed in Japan.

Besides a speech interface, the use of speech recognition technology in business applications is still advancing considerably. In the Japanese House of Representatives, speech recognition technology developed by Kyoto University has already been introduced to create Diet Session Proceedings. [95] Moreover, it is being used to check whether call center recordings contain inappropriate language[96] and to transcribe a doctor's speech when interpreting X-ray images[97] (obtaining diagnostic findings by examining images). The latter is a situation in which it is difficult to use a PC for input as it is done in a darkroom; furthermore, since speech recognition performance does not degraded because the room is quiet and it does not disturb people working together, it is a

---

91 "Shabette Concier (in Japanese)" NTT DoCoMo website <https://www.nttdocomo.co.jp/service/shabette_concier/>

92 "Voice Assist (in Japanese)" Yahoo! JAPAN website <https://v-assist.yahoo.co.jp/>

93 Inago website <http://www.inago.com/>

94 A contest competing to develop conversation applications that can be used on Amazon's speech interface "Alexa." For university, the total prize balance is 2.5 million dollars (approximately 280 million yen) (Converted at 1 dollar equal to 113 yen based on official rate reports for December 2017). "The Alexa Prize." Amazon.com Website <https://developer.amazon.com/alexaprize>

95 "Introduction of Kyoto University's speech recognition technology in the new proceedings recording system in the House of Representatives (in Japanese)," 2011.5.12. Kyoto University website <http://www.kyoto-u.ac.jp/static/ja/news_data/h/h1/news6/2011/110512_2.htm>

96 "Sales begin of the "Contact Centre Business Efficiency Improvement Support Service (in Japanese)," which converts and utilises the contents of calls between customers and operators to text in real-time." 2017.3.23., Hitachi Ltd., website <http://www.hitachi.co.jp/New/cnews/month/2017/03/0323a.html>

97 "AmiVoice Ex7 Rad and AmiVoice Ex7 RadClient for Radiology Readings Reports (in Japanese)," Advanced Media, website <http://medical.amivoice.com/product/rad.html>

good practice due to an excellent match between needs and application. Companies such as Nuance[98] in America, and Advanced Media[99] and FueTrek[100] in Japan are known for their development and sales of this technology.

3. Real-world Applications

（1） Car Navigation

Voice-operated in-car navigation is a field of application that has been focused upon in Japan. As a forward-gaze is necessary when driving, the need for voice operation is high.[101] Voice navigation began to be equipped in-car navigation systems around 1995,[102] and Japanese automobile manufacturers began research and development; however, the evaluations of the speech recognition capabilities of built-in type car navigation systems were unfavorable.[103] One of the reasons for this, with a (highly demanding)[104] background of an automobile industry that attaches importance to safety and a corporate culture where "we cannot release imperfect products," is that the systems have been developed as the systems that did not use the Cloud (i.e., a system operating even where communications cannot be ensured), and hence, it has not been possible to update speech recognition dictionaries nor map data, and also to collect data from users. Conversely, car navigation applications that run on smartphones continue to widely spread.[105]

（2） Robots

In Japan, which has a high cultural affinity for humanoid robots,[106] with the release of the voice-interactive robot "Pepper," there are great expectations for robots that combine speech recognition technology and robot engineering. Moreover, conversation robots are also expected to be applied to nursing services, etc.[107] Owing to the growing issue of declining birthrates, it is a technology Japan requires.

---

[98] Nuance Communications website <https://www.nuance.com/>

[99] Advanced Media website <https://www.advanced-media.co.jp/english>

[100] FueTrek website <http://www.fuetrek.co.jp/en/>

[101] However, similar to the robots described later, the degree of difficulty of performing speech recognition in the environment inside a car is greater than with a smartphone. For example, speech is often input to a smart phone very close to the user's mouth, and hence, the mixing of noise is comparatively small, but inside the vehicle, engine noise, wind noise, music inside the car etc., are mixed.

[102] Ichiro Akahori "Development of Speech Recognition for Car Navigation System (in Japanese)" Information Processing Society of Japan Research Report Audio Language Information Processing, 2005-SLP-058, 2005.10, p. 31. <https://ipsj.ixsq.nii.ac.jp/ej/?action=repository_uri&item_id=56972&file_id=1&file_no=1>

[103] According to the survey company J.D Power, 19% of voice operation users felt it to be faulty, and the share of users using voice operation fell from 29% (2016) to 26% (2017). Customer satisfaction survey of automobile manufacturer's own navigation systems, Lexus, Subaru ranked number 1. Operability when connecting a smartphone and improvement of speech recognition capability performance are important issues (in Japanese). 2017.10.6, p. 2. J.D. Power website <http://japan.jdpower.com/sites/default/files/17_jp_navi-oem_pr_j_fnl.pdf>

[104] For example, a developer of a vehicle-related manufacturer, even where the average speech recognition rate is 99%, for a specific speaker with a low recognition rate, the product is unsatisfactory, and it is stated that it is difficult to accept it as a product. Akahori, *supra note* (102), pp. 31-32.

[105] "How much can you rely on free smartphone navigation applications? Review of two popular applications (in Japanese)," 2015.1.28, Toyo Rubber Industries, <http://www.toyo-rubber.co.jp/ontheroad/drive/978/>; Tsunetake Noma "Navigation by smartphone, traffic information on the latest maps, tunnels a weak point," Nikkei Style, 2017.6.13. <https://style.nikkei.com/article/DGXMZO17221990S7A600C1000000>

[106] "Robots, AI and the Future, Awaji Symposium (in Japanese)" Nihon Keizai Shinbun, 2017.8.9, p. 9.

[107] "Wide-scale proof of concept test of the usability of "communication robots" in nursing care, introducing 1,

However, the technical difficulty of speech recognition is dramatically different between speech recognition with a microphone near the speaker's mouth, as in a smartphone, and speech recognition when speaking to a robot located away (remote speech recognition). Specifically, there are issues of reverberations in the room, reflection of sound, inclusion of background noise, etc. Therefore, beyond laboratory-level conversation robots, further research is necessary to realize conversation robots used by a wide range of real users.

Note that the smart speakers described above may be a possible pivot toward realizing this kind of conversation robot. This is because, through smart speakers, large amounts of speech data in the environment of the usage of general users and those from distant locations can be collected. However, the extent of usage of the smart speakers is as yet unknown, and it is unclear whether it will produce data useful for application to a conversation robot.

(3) Speech Translation

Speech translation combining machine translation and speech recognition is a further promising area of application. Although speech translation of typical sentences has already been implemented,[108] consideration for the contexts included in culture in translation is difficult even for humans, and it is not believed that this can be achieved simply by improvement through deep learning. To realize this kind of translation, steady academic research is necessary, including pragmatics in linguistics and the ways in which humans use language.

4. Privacy Issues

Privacy issues arise from always-on smart speakers.[109] This is because, unlike in smartphone applications where speech recognition (i.e., recording) is only performed when the user launches the application, speech data can be uploaded to servers of service providers at any time. With regard to this kind of problem, in Japan, only the risk aspects tend to be emphasized without careful discussion and enough understanding, which hinders development and adoption. This results in widespread of services originating overseas.

Kazunori Komatani, Osaka University

V Human−Agent Interaction

1. Notable Social Background

(1) Basic Definition

000 robotic units, supporting the collection and analysis of various data (in Japanese)." 2016.3.17. Japan Agency for Medical Research and Development website <https://www.amed.go.jp/news/release_20160317.html>

[108] "First-aid speech translation application "First Aid Voice-Tra" for fire departments nationwide! (in Japanese)" 2017.4.18., National Institute of Information and Communications Technology website <https://www.nict.go.jp/info/topics/2017/04/170418-1.html>

[109] "Concerns for privacy over AI speakers listening to family conversations (in Japanese)," 2017.9.4. Nikkei CrossTech website <http://tech.nikkeibp.co.jp/it/atcl/watcher/14/334361/083100911/>

Human–agent interaction (HAI) is a field of research addressing the interaction between human beings and man-made objects, using information processing, engineering mechanical control technologies, and applied psychology techniques to personify man-made objects; it is a design method developed to realize cordial and smooth communications akin to conversation between people.[110] Specifically, it handles humanoid robots and virtual agents.[111]

For systems to replace humans, there are AIs that substitute for brains, and materials, configuration designs, and machine controls that substitute for bodily function. HAI research aims to realize AI with humanity, including emotions, and systems with a physical body and expressive ability through gestures and expressions accompanying an internal "heart" state. Thus, HAI can be described as the psychological / physical interface, a container for encapsulating an artificial intelligence and producing external interaction, necessary to create the ultimate artificial human being. It is an important field of research for the wide dissemination of AI to general users.[112]

（2）Social Background

Since the 1960s, dialog system technology, as the human interface handling the point of contact between people and computers and in the field of human–computer interaction, has progressed from text conversations[113] to spoken conversations[114] and ultimately face-to-face conversation, imparting physicality to spoken conversation.[115] In particular, between the 1990s and 2000s, influenced by the development of robot control technologies, various humanoid robots appeared. For example, Kismet,[116] developed by the American Massachusetts Institute of Technology, (MIT), is a robot that combines sociability and physicality and can recognize human emotions at the same time as expressing its own.[117]

Through the development of this kind of interactive conversation system combining physicality and sociability, the system is highly anthropomorphic, can convey easy-to-understand information in lieu of people, and appears familiar to humans.[118] Such a system, by providing substitute services, in interpersonal work such as secretarial or call-center work, as conversation partners for the elderly, as counselors, and as everyday partners or pets in the home, can enrich human life. Moreover,

---

110 "Overview." Human-Agent Interaction Website <http://hai-conference.net/>

111 A dynamic, interactive system for the presentation of virtual characters through computer animation

112 The Japanese Society for Artificial Intelligence *supra note* (3), pp. 870-873.（Seiji Yamada, "Human-Agent Interaction"）(in Japanese)

113 Joseph Weizenbaum, "ELIZA: a computer program for the study of natural language communication between man and machine," *Communications of the ACM*, Vol. 9 No. 1, 1966.1, pp. 36-45.

114 Tatsuya Kawahara, Masahiro Araki, The Japanese Society for Artificial Intelligence, "Speech Dialog System (Cognitive Science)," *Ohmsha*, 2006

115 Shigeki Sagayama et al., "Galatea: An Anthropomorphic Spoken Dialogue Agent Toolkit" *Information Proces sing Society of Japan, Spoken Language Information Processing*, 2002-SLP-045, 2003.2, pp. 57-64. (in Japane se) <https://ipsj.ixsq.nii.ac.jp/ej/?action=repository_uri&item_id=57254&file_id=1&file_no=1>

116 "Through changing its facial appearance, it is possible for the robot to create expressions through movement of the eyebrows, eyes, mouth and ears." Cynthia Breazeal and Brian Scassellati, "A Context-Dependent Atte ntion System for a Social Robot," *Proceedings of the 16th International Joint Conference on Artificial Intelli gence*, 1999, pp. 1146-1153.

117 For details about physicality and sociality, see the following literature. eds., Michio Okada et al. "Physicalit y and Computers" *Kyoritsu Publishing*, 2001; Cynthia Breazeal, "Toward sociable robots," *Robotics and Auto nomous Systems*, Vol.42 No.3-4, 2003.3, pp. 167-175. (in Japanese)

118 Seiji Yamada, "Design between Humans and Robots," *Tokyo Denki University Press*, 2007 (in Japanese)

research on such systems, clarifying cognitive frameworks from the perspectives of human cognition and thought, includes the possibility of contribution to the development of computer science.[119]

2. Research Fields

In this section, fields of research of particular importance to sociality and physicality in HAI are described.

（1） Sociality

Research on sociality is to analyze human psychology when aiming for mutual understanding while recognizing oneself and others, and to reflect that knowledge in the system. As a field of research, there is fundamental research related to the mechanisms by which people perceive a system as being capable of conversation, and recognizing the system as another entity distinct from themselves. These are systems that recognize the other party as having a mind, or a mechanism to gauge the intent of the other party (understanding of others),[120] or a mechanism to understand what kind of ways of thinking and beliefs form the basis of the other party (other-party models)[121] etc., and this kind of research is strongly linked to fundamental research related to explaining the "mind." Moreover, based on developmental research of recent years, it is also related to research fields in cognitive scientific analysis[122] and the explanation of mechanisms that make interpersonal communication difficult[123].

Research on sociality is also related to research on participation structures,[124] i.e., the ways in which conversation partners behave during conversation, and research on multi-agent systems[125] clarifying decision-making mechanisms in group discussions.

These studies are important for high-compatibility AI interfaces with people, which alongside basic communications research on reading, understanding, and sympathizing with the other party, are important for incorporating these into all of society's systems.

（2） Physicality

Research related to physicality has the aim of realizing various physically embodied expressions

---

[119] Yuichiro Anzai, "Cognitive Science and Artificial Intelligence" Computer Science / Software Technology Course 17, Kyoritsu Publishing, 1987 (in Japanese)

[120] E.g., Masuo Koyasu et al., 'Theory of Mind," The process before and after of understanding others' minds - Investigation through case analysis, *Bulletin of the Graduate School of Education, Kyoto University*, No. 46, 2000.3, pp. 1-25. (in Japanese) <http://hdl.handle.net/2433/57383>

[121] Kim Bartholomew, "Avoidance of Intimacy: An Attachment Perspective," *Journal of Social and Personal Relationships*, Vol. 7 No. 2, 1990.5, pp. 147-178.

[122] Junichi Yamamoto, Chieko Kasumoto "Development and Support for Autism Spectrum Disorders," Cognitive Science, Vol. 14, No. 4, 2007, pp. 621-639. (in Japanese) <https://doi.org/10.11225/jcss.14.621>

[123] Watanabe Ayako et al., "2A1-E24 Discovery of Facial Characteristics and Preference Acquisition - Learning model for autistic children through applied behaviour analysis - (Cognitive Robotics), *Robotics & Mechatronics Lecture Presentation Summary*, 2008.6. (in Japanese)

[124] Enomoto Mika, Yasaharu Tera, "Analysis of Non-verbal Behaviours Involved in 3-Person Conversation when Substituting Roles," Language and Speech Understanding and Dialogue Processing Research Society, The Japanese Society for Artificial Intelligence Document, No. 38, 2003.7, pp. 25-30. (in Japanese)

[125] See Chapter VIII, Multi-Agent Systems. Besides refer to Masahiro Takahashi, Nakamori Akira, "Multi-Agent Consensus Formation under Individual Irrationality," Transactions of the IEICE, D1, Information Systems., I, Information Processing, Vol. 82 No. 8, 1999.8, pp. 1093-1101. (in Japanese)

in communication with people through touch and sight, obtaining information during exchanges with other parties, understanding the situation, changing internal states such as emotions, and performing autonomous actions, through a system connected to a "mind," namely, "interface agents."[126]

Researches on the means by which HAI can express emotions, perform robot control, computer graphics, and analysis, recognize facial expressions etc., are advancing. It is well-known that human beings, when communicating with a particular target, are strongly influenced by the target's outer appearance and behavior when making assumptions about the intelligence and mental capabilities of the target.[127] If the physical properties of the HAI are inadequate, the system may be regarded as a mere AI lacking a human-like mind, thus affecting its acceptance, and hence, research related to physicality is important.

3. Real-world Applications

Medicine, education, nursing, sports, and interpersonal services are highlighted as fields in which applications of HAI are being considered. In these fields, cordial, smooth communications with people may increase the evaluation of these services, and future humanoid robots and virtual agents incorporating HAI may be accepted as a new mode of "human resources." As HAI is expected to have the ability to understand the mindset of the other party, it is expected to have particular application to fields relating to the analysis and treatment of the mind: psychology, cognitive science, psychiatry, and mental health counseling. The use of agents possessing emotional intelligence and emphasizing sociality in light of the other party's emotions, in listening, counseling, or as pets is expected to bring spiritual stability through relations with others, amidst a social environment in which familial nuclearization and societal aging are advancing.

Domestic robots can be cited as an application arising from the early application of HAI. This is because, when compared with applications in medicine etc., less stringent technological development is considered permissible. Japan is strong in content creation technologies for animation and game industries, and is also strong in character design for anthropomorphic content. Moreover, with many Japanese researchers participating in the international HAI development community, Japan is positioned as a world leader.[128] Therefore, it is important to advance research and development of HAI and its application while fully utilizing Japan's fields of specialism.

4. Future Issues

There are technological and ethical issues related to HAI. With regard to technological issues, for society to begin to accept humanoid robots and virtual agents in lieu of people, improvement of

[126] Kenji Mase et al., "A Basic Study on Interface Agents," *Information Processing Society of Japan Research Reports Human Interface Society Report*, 1996-HI-069, 1996.11, pp. 55-60. (in Japanese) <https://ipsj.ixsq.nii.ac.jp/ej/?action=repository_uri&item_id=37311&file_id=1&file_no=1>

[127] Jeremy N. Bailenson et al., "The independent and interactive effects of embodied-agent appearance and behavior on self-report, cognitive, and behavioral markers of copresence in immersive virtual environments," *Presence: Teleoperators and Virtual Environments*, Vol. 14 No. 4, 2005.8, pp. 379-393.

[128] "Steering Committee." Human-Agent Interaction Website <http://hai-conference.net/steering/>

both the physical expressive ability (physicality) and ability to comprehend others (sociality) are cited.

With regard to ethical issues, where it is viewed that humanoid robots and virtual robots live like humans, there is the issue of a need to distinguish between the ethical attitudes required by people and by equipment and systems such as these, and those developed up to now. When devices and systems deemed human are treated improperly or inhumanely, it may form impressions on third parties or influence their psyche, and there is the possibility that this may adversely influence the morals of human society. Furthermore, from the equipment / system usage side, there is the possibility that the ability to understand human psychology could be exploited to influence human behavior through fraud, brainwashing etc. Not only must the personal ethics of equipment and system designers be questioned, but a basic framework must also be constructed for the expression of emotion and appropriate designs related to ethics for such systems and equipment must be developed.[129]

Tomoko Yonezawa, Kansai University

VI Robots

1. Notable Social Background

(1) Definition of "Robot"

A broad definition of the technical concept of "robot" is most appropriate, without being limited to the robots drawn in anime or manufacturing machines used in factories, rather as "an information machine that interacts with physical space." In the past, robots were, in many cases, defined with a focus on underlying technologies such as sensors, controls, and autonomous movement; however, with the rapid development of information technology, this definition does not capture the full breadth of robots that can be developed. With regard to automobiles, for example, automated driving is an apparent application, but intelligent functions such as preventing accidental pedal application, automatic braking, and automatic wipers, are also applications of robot technology. Moreover, intelligent rooms, i.e., rooms equipped with sensors (sensory devices) and actuators (motion devices) providing various services in response to human actions are also a type of robot.

Furthermore, there may be cases where the functionality of robots is not limited to physical entities. For example, some functions such as speech recognition, as in smartphone speakers[130] using AI, also implement processing using cloud computing[131] over the internet, and the various functions of sensors, cognition, control, and movement are physically dispersed. It is increasingly common to refer to these in general as robots.

---

[129] Kukita Minao, "Possibility of Robotic Ethics," Bulletin of Kyoto University Faculty of Letters Department of Philosophy, No. 11, 2009.3. <https://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/71114/1/prospectus11_Kukita.pdf>

[130] Speakers that allow operation of household appliances, and listening to news and music through voice operation while connected to the internet. See Chapter IV Speech Interfaces and Chapter VII IoT.

[131] See Chapter VII IoT, 1(2) Improvements to Infrastructure Environment

Thus, technology, machine control, information processing, and intelligent processing contribute to a robot.

(2) Recent Trends around Robots

Robotic technology was almost entirely limited to manufacturing equipment applications; however, in recent years, a wide range of applications has been developed,[132] and robots have gradually come to be regarded as familiar things. The technologies making broad contributions to this field of application are primarily computer miniaturization, faster computing, semiconductors, micro-electro-mechanical systems (MEMS),[133] and similar technologies, whose development has led to the miniaturization and greater functionality of devices. The acceleration of computing, in particular, allows the real-time digital processing of complex behavior controls, making robots operable even outside of factory environments constructed specifically for robots. Indeed, with the progress of AI and interfaces, it has become possible to execute complex tasks and functions. Consequently, possible applications requiring interaction with humans, such as household and nursing applications, are expanding.

Furthermore, the application of robotics technology to various specific needs is expected to address issues of aging, population decline, and growing international competition. Nursing robots and autonomous vehicles are expected to be direct solutions to an aging society. The use of robots in the fields of infrastructure, civil engineering, and construction is believed to be essential for compensating shortages in human labor. In addition, work in high-radiation environments, such as the cleaning up after the nuclear accident caused by the Great East Japan Earthquake, cannot be performed by means other than robots, and a wide range of technological developments are desirable.

Even internationally, the development of robotic technology is advancing rapidly, focusing on the fields of manufacturing, distribution, and logistics, such as "Industrie 4.0"[134] promoted by the German federal government and Amazon's automated warehouses. In China, Korea, and Southeast Asia, robot technology is being treated as a source of international competitive advantage, and in each country, technological development is being strengthened.

Moreover, robot competitions are also drawing attention as catalysts for technological development and education. Various international robot competitions have been held over the past 20 years, starting with the RoboCup (since 1997),[135] various competitions held by the DARPA,[136] the European Robotics League (since 2016)[137] held in Europe, etc. In Japan too, the World Robot

---

132 "Future market forecast of robotics market released, expected to grow to ¥9.7tn by 2035," 2010.4.23. New Energy and Industrial Technology Development Organisation (NEDO) website: <http://www.nedo.go.jp/news/press/AA5_0095A.html> (in Japanese)

133 A microelectronic device where the electronic circuits, mechanical structure, and sensors are integrated on a single circuit board

134 Industrie 4.0 Website <http://www.plattform-i40.de/I40/Navigation/EN/Home/home.html> See Chapter VII IoT, 3. Practical Social Applications

135 RoboCup Federation Website <http://robocup.org/>

136 The autonomous vehicle races "Grand Challenge" (2004,2005), "Urban Challenge" (2007), and the "Robotics Challenge" (2012) in which humanoid robots compete in tasks, were held.

137 European Robotics League Website <https://www.eu-robotics.net/robotics_league/>

Summit is planned for 2018 and 2020[138]. Amazon has hosted the Amazon Robotics Challenge, encouraging technological development to advance its automated warehouses.[139]

2. Technology Trends

As robotic technology is a combination of various underlying technologies and their integration in addition to design technologies, technological trends for each technology are described.

（1） Sensing Technology

Sensing is a technology used by robots to recognize states in the outside world. Identification technology using machine learning techniques such as deep learning has been a remarkable development in recent years.[140] In particular, image recognition, video recognition, and speech recognition performance corresponding to robotic sight and hearing has advanced rapidly in the past 10 years.[141]

The most important factors in machine learning performance are the volume and quality of data,[142] and data collection and aggregation are of utmost importance to the improvement of sensing technology.

（2） Locomotive and Handling Technology

Flight technology, as represented by rotary-wing type flying robots (so-called “drones”) has progressed remarkably in recent years as a technology handling robot movement.[143] The history of flying robot research is long; however, in recent years, the development of flying robots has advanced rapidly and their use is expanding through the miniaturization and acceleration of control computers owing to advances in computing technology. Currently, technological development of more sophisticated control technology and controls for multiple flying robots is being undertaken.

While wheels account for the majority of terrestrial movement methods, research and development of legged robots, including bipedal robots that can operate in the same work spaces as people, is also advancing. In particular, America’s Boston Dynamics and Japan’s SCHAFT’s legged robots are complete, and have attracted much attention.[144]

For actuators, currently, motors are used in nearly all cases; however, research is advancing for

---

138 World Robot Summit website <http://worldrobotsummit.org/>

139 Amazon Robotics Website <https://www.amazonrobotics.com/#>

140 See Chapter 1, Knowledge Processing & Machine Learning

141 For image recognition and video recognition see Chapter III, Image Recognition & Processing, for Speech Recognition see Chapter IV, Speech Interfaces

142 Kazunori Ohno et al., “Data Engineering Robotics - Sensor Data Produce New Robot Intelligence,” Transactions of the Robotics Society of Japan, Vol.33 No.2, 2015.3, pp.97-99. <https://www.jstage.jst.go.jp/article/jrsj/33/2/33_33_97/_pdf> (in Japanese)

143 “Report: Frontiers of Robotic Flight Research (1),” Journal of the Robotics Society of Japan, Vol. 34 No. 1, 2016.1, pp. 1-32 (in Japanese); “Report: Frontiers of Robotic Flight Research (2),” Journal of the Robotics Society of Japan, Vol. 34 No. 2, 2016.3, pp. 1-60 (in Japanese); Kenzo Nonami, “State of the art and issue of drone technology and business frontier,” Information Processing, Vol. 59, No. 11, 2017.2, pp. 755-763. <https://www.jstage.jst.go.jp/article/johokanri/59/11/59_755/_pdf/-char/ja> (in Japanese)

144 Both companies were under the umbrella of Alphabet, the holding company of Google; however, it was reported in June 2017 that it was acquired by Japan’s Softbank Group. “RoboVB2 acquired by Softbank from Google” Nihon Keizai Shimbun, 2017.6.9, evening edition, p.1. (in Japanese)

next-generation actuators achieving smoother, flexible movements.[145] Particularly in cases where robots operate while in contact with human beings, research on artificial muscles that can achieve movements with a high affinity to human movements is advancing.

(3) Behavior Planning (Action Planning)

Methods for intelligently planning robotic movements are being developed. In this field, to enable complex processing and high-efficiency actions, research and development, in addition to implementation, of design planning for the coordinated movement of multiple robots and multiple actuators are being advanced.

Cooperative action planning is also important for cooperation between robots and people. In recent years, manufacturing robots that operate in cooperation with people have been commercialized,[146] and it is expected that the development of technology for controlling robots in synchronicity with human movements will advance in the future.

Moreover, as autonomous vehicles and flying robots become commonplace, negotiation technology for coordinating movements between robots will also become necessary. The negotiation technology between AIs necessary for coordination between robots has also been undertaken as a development theme by the Council on Competitiveness-Nippon (COCN).[147]

(4) Integration and Design Technology

In robotic technology, balanced integration technology and design technology are also important. "Design" as used herein refers not only to looking good, but also to a comprehensive design including ease of maintenance and operation. Compared with general information devices, in robots, it is important to reconcile the size, weight, and shape of each part. Operational ease, such as a balanced integration combining purpose and application, maintenance of moving parts, adjustment of sensors, etc., are also important technical requirements. Therefore, many companies are primarily engaged in the integration of robotic technology according to its purpose and application.[148]

Moreover, as the internet and cloud computing are becoming commonplace, it is no longer necessary to limit robots to only robotic function. For example, by performing speech recognition, image recognition, action planning etc., on the cloud over the internet, advanced and complex processing and operation can be achieved. The integration of this kind of internet technology is also an important element of integration technology.

---

[145] "Report: Future Images Drawn by Next-Generation Actuators" Journal of the Robotics Society of Japan, Vol. 33 No. 9, 2015.11, pp. 1-34 (in Japanese).

[146] "DENSO WAVE's first human-cooperative robot, "COBOTTA" begins accepting orders Wednesday 29th November" website <http://www.denso-wave.com/ja/info/detail__1000.html> (in Japanese); "Release of human-cooperative robot MOTOMAN-HC10,"2017.6.8. Yaskawa Electric Corporation website <https://www.yaskawa.co.jp/newsrelease/product/31940> (in Japanese); "Human-robot collaboration (HRC)." KUKA Website <https://www.kuka.com/en-us/technologies/human-robot-collaboration> (in Japanese)

[147] Council of Competitiveness - Nippon (COCN) "Interim report for 2017, AI negotiation, coordination and cooperation," 2017.10.13. <http://www.cocn.jp/thema98-M.pdf> (in Japanese) COCN, consisting of volunteers from industry, make policy recommendations for science and technology policy and industrial policy.

[148] Yushi Segawa, "An Introduction to Industrial Trends on Robot System Integration Overseas," Journal of the Robotics Society of Japan, Vol. 33 No. 5, 2015.6, pp. 306-309 (in Japanese).

（5） Software Standardization

Robots have diverse underlying technologies and functions, and software for their flexible combination according to purpose and use; the standards that form the basis for development of such software are gaining importance. The robot operating system (ROS)[149] and robot technology middleware (RTM)[150] are software standards for robotics use. ROS is being developed with a focus on the US, and is currently the most widely used standard. Japan is primarily leading the development of RTM, and has strengths in fine control requiring rapid responses. Moreover, tools to bridge ROS and RTM are also being developed.

Simulation software is also important. "Gazebo," based on ROS,[151] and "Choreonoid,"[152] based on RTM, are softwares used to perform general robot simulation. Both of them can be applied to various robots, and can be used for the development of robot software. In addition, "SIGVerse," which can simulate interactions between robots and people, is also being developed.[153] As the number of robots working together with people is expected to increase in the future, the existence of these kinds of simulation software is important.

3. Real-world Applications

（1） Manufacturing Fields

In the manufacturing field, it is believed that the use of robots involved in the manufacturing process cooperating with people will increase in the future. In particular, to facilitate the transition to high added-value, low-volume multi-product production, it is possible that the processing of products by robots and humans simultaneously will become commonplace.

Moreover, items requiring fine pressure adjustment such as gear meshing, and soft objects such as textiles and food are difficult for robots to handle. Research to overcome this is currently being undertaken.

（2） Application to Harsh Environments

Much of the work performed in harsh environments such as disaster area restoration and nuclear accident clean-up cannot be performed without robots, and hence, their wide use in these applications is expected. Especially in the decommissioning process of the reactor at Fukushima Daiichi Nuclear Power Plant, as the majority of this activity is to be undertaken in environments where humans cannot enter, robot development is an urgent priority.

Moreover, to deal with future population decline and labor shortages, the development of robots to replace labor in harsh environments is further important. Specifically, applications to infrastructure maintenance, public works construction sites, and agriculture are expected.

---

149 ROS.org Website <http://www.ros.org/>

150 OpenRTM-aist Website <http://www.openrtm.org/openrtm>

151 Gazebo Website <http://gazebosim.org/>

152 Choreonoid homepage（From Shinichiro Nakaoka, Senior Researcher at the National Institute of Advanced Industrial Science and Technology） <http://choreonoid.org/ja/> http://choreonoid.org/>

153 SIGVerse website （From Tetsuya Inamura, Associate Professor at the National Institute of Informatics） <http://www.sigverse.org/wiki/en/>)

（3） Traffic and Transportation

Research and development of practical applications of autonomous vehicles is being actively promoted by enterprises and universities in various countries. Technologies such as automatic braking and automatic parking have already been adopted; however, there are expectations that, in the future, autonomous vehicles with a higher degree of autonomy will be put into use, and investigations into social acceptability and methods of usage are becoming a topic of conversation.[154]

The use of robots at transportation sites has already been partially realized in Amazon's automated warehouses, and the realization of fully automated warehouses is expected in the near future.[155] In the future, technological development including automation outside warehouses, cooperating with autonomous vehicles etc., is expected to become a topic of research.

（4） Nursing and Welfare

In the fields of nursing and welfare, robots supporting the movements of the elderly and disabled have reached a practical level and several products have already been developed.[156] In addition, the practical use of robots in particular nursing care scenarios, such as meal support, is progressing.[157] However, such robots support only a single function, and the excessive expectations of robots' ability to reduce the burden of nursing care must be treated with caution.[158]

（5） Homes and Offices

The use of robots in homes and offices is also increasing. With particular regard to cleaning and security, many commercial robots have already been put into practical use. With regard to guidance robots, in particular, owing to the opportunity afforded by events such as the 2020 Tokyo Olympics and Paralympics, there is the possibility to expand the use of robots equipped with multilingual speech interfaces aimed at foreign visitors.

Moreover, many types of robot partner products[159] are being put to practical use in communicating with people and supporting human activities, and examples of practical applications are expected to expand rapidly in the future.

---

154 "Trends and Challenges in Automated Vehicle Technology - Research Projects on Science and Technology 2017 Report, "(in Japanese) Investigation Report April 2018, National Diet Library Research and Legislation Examination Bureau, 2018 addresses technical trends in automated vehicles and addresses various issues.

155 "STARTupX (3) Logitech, Warehouse robots perform the most unmanned sorting, unlimited package shapes using 3D recognition," Nikkei Sangyo Shinbun, 2017.11.18, p. 1; "Robots for extracting and packing products, UK online supermarket," 2017.12.10. Nihon Keizai Shinbun Electronic Edition <https://www.nikkei.com/article/DGXMZO24362230X01C17A2000000/>_(in Japanese)

156 E.g., "The world's first cyborg robot 'HAL,'" CYBERDYNE website <https://www.cyberdyne.jp/products/HAL/>_(in Japanese)

157 E.g., "Meal support robot 'My Spoon,'" Secom website <https://www.secom.co.jp/personal/medical/myspoon.html>_(in Japanese)

158 Shigeru Yamauchi "Nursing Robots, The Current Situation and Challenges," Conference materials for the 2nd Bureau of Social Welfare and Public Health study on forms of regional comprehensive care systems towards implementation in Tokyo, 2015.7.30, pp. 4, 14., Tokyo Bureau of Social Welfare and Public Health website <http://www.fukushihoken.metro.tokyo.jp/kourei/shisaku/chiikihoukatsukaigi/02chiikihoukatsukeakaigi.files/06yamauchisama.pdf>_(in Japanese)

159 "Partner Robot" Toyota Motor Corporation website < http://www.toyota-global.com/innovation/partner_robot/>

4. Concerns

Although not necessarily limited to discussions of robots, improvements to the legal system concerning necessary safety protections and determining responsibility for issues arising from the applications of cutting-edge technologies are slow, and there are concerns that this will hinder their popularization. For example, in the case of traffic accidents caused by autonomous vehicles, no social consensus has been reached as to who bears the burden of responsibilities so far attributed to the driver, or how to proceed in this regard, nor are there legislative provisions. As autonomous driving technology is the core of national next-generation industry, it is necessary to develop legislation as soon as possible to maintain international competitiveness.[160]

Itsuki Noda, National Institute of Advanced Industrial Science and Technology

Ⅶ Internet of Things

1. Notable Social Background

The term "Internet of things" (IoT) appeared around 2000, and originally indicated a device with internet connection capabilities; however, nearly 20 years later, the term has assumed various meanings, as a concept, as a service, and as equipment, and it is becoming difficult to define it in a single word. The air-conditioning control system made by the American company Nest is a famous typical example of IoT. The air-condition control device, connected to the internet, has given rise to new services not only automatically controlling the air-conditioning in each household, but also controlling the power consumption of areas during peak times.[161] Here, devices (IoT devices) with internet connection capabilities are described, in addition to the services using them. Similar terms include cyber physical systems (CPS),[162] machine-to-machine (M2M),[163] and ubiquitous computing.[164] The following four factors are aspects of social background where IoT has gathered attention.

（1）Communications Cost Reduction

To reduce both energy consumption and cost, IoT devices connect to surrounding network connections using Wi-Fi (wireless LAN) or BLE (Bluetooth low energy) rather than by LTE, and these are necessary to send data to the cloud. With the increase in the adoption rate of devices equipped with Wi-Fi and BLE such as smartphones, smart watches (wrist-watch type wearable devices), and activity trackers (wearable devices measuring daily activity), the cost of

[160] "Responsibility hurdles prevent autonomous driving, disputes over accidents, steep roads," Nikkei Sangyo Shinbun, 2018.2.22, p. 2 (in Japanese).

[161] "Nest's Smart Home, Advances in the field of Solar Power," Forbes Japan, 2015.5.8. <https://forbesjapan.com/articles/detail/3942>

[162] A broad concept that collects data from sensors installed in the real world (physical space) in the cloud (cyberspace) via the internet, and feeds the results of analysis back into the real world.

[163] A term mainly concerned with factories, indicating that machines are interconnected via a network and coordinate movements between one another.

[164] Ubiquitous computing refers to installing processors in various things around us, connected to the internet.

communication modules has decreased.

As such, it is becoming easier to equip devices thus far not equipped with communications capabilities with such capabilities, and an environment for the installation of IoT devices is in place.

(2) Improvement of the Infrastructure Environment

One of the tasks for the spread of IoT has been the accumulation of data from IoT devices, and in 2006, Amazon's Amazon Web Service (AWS) was released into the market as a cloud environment in which to accumulate this data, resulting in dramatic changes since then.[165] The pricing of AWS is based on a volume-of-use system, which makes introducing IoT services into the market easier because it is possible to flexibly increase performance when expanding the service, while reducing the cost of cloud computing during the dawn of the service. Subsequently, Google and IBM released similar services, and it became possible to offer IoT services without building a cloud environment oneself. Moreover, the computational resources necessary for deep learning, etc. are also available in the cloud, and barriers to market entry have become extremely low.

(3) Spread of Digital Fabrication and Crowdfunding

When doing business, money and objects are important factors. Devices such as 3D printers[166] have become widespread, and based on design data, objects can be created inexpensively with a high degree of freedom, making ideas easier to implement. This technology is called digital fabrication. Through the widespread usage of crowdfunding,[167] fundraising for the commercialization of prototypes created through digital fabrication has become straightforward. These trends are one of the factors making it easy to commercialize IoT services.

(4) AI Technology Development

Using data gathered from IoT devices, it is believed that it is possible to create new value. For example, with the recent progress of AI technology, there are increasing expectations for new IoT services applying AI that has learned from data gathered from IoT devices to produce various insights and judgments.

2. Technology Trends

(1) Communications Technology

The majority of household IoT devices use Wi-Fi as their communications method, because of their high degree of market penetration and inexpensive communications chips. However, the communications range of Wi-Fi is inadequate for IoT devices performing communications outdoors or across wide areas. Therefore, wireless communications technology covering wide areas using low power consumption, known as a low-power wide area (LPWA) network, is continuing to expand.[168]

---

165 Ministry of Internal Affairs and Communications, *supra note* (1), p. 91. <http://www.soumu.go.jp/johotsusintokei/whitepaper/ja/h28/pdf/n2200000.pdf> (in Japanese)

166 A machine that produces three-dimensional models by stacking layers one by one, based on 3D design data.

167 A mechanism through which funding is solicited from many people over the internet.

168 Ministry of Internal Affairs and Communications, "White Paper on Information Communications, 2017 Editio

LoRaWAN, SIGFOX, and NB-IoT can be cited as representative examples of LPWA. LoRaWAN offers communication speeds of approximately 250 bps and a communications range of approximately 10 km. In Japan, the three major mobile telecommunications companies have launched services used by multiple businesses, and this can be said to be the most widespread LPWA. The biggest feature is that because a radio operator's license is not required (as with Wi-Fi), anyone can set it up, and in such cases, communication fees are unnecessary. SIGFOX, like LoRaWAN, is a wireless communications technology that does not require a radio operator's license. Compared with LoRaWAN, it has slower communication speeds of approximately 100 bps, but a wider communications range of approximately 50 km. It is mainly used for IoT devices using small volumes of data such as water meters, etc. NB-IoT is an extension of the LTE[169] communications method used by mobile phones aimed at IoT, with communication speeds of approximately 100 kbps and communications range of approximately 20 km. As it can use existing LTE base stations, it has the advantage of being able to cover the entire country. However, as it requires a radio operator's license, its adoption has been mostly limited to telecommunications companies.

（2） IoT Devices

In IoT devices, a control device for regulating the device over the internet is required. Circuit boards,[170] which form the basis of the development of plans, and prototypes of these kinds of control devices have already become widespread, and sensors and communications modules that can connect to them are sold inexpensively. Thus, it has become possible for anyone to prototype IoT devices easily.

Instances where IoT devices are being sold as finished goods are also increasing. Locks that can be controlled remotely from smartphones (smart locks), surveillance cameras, and internet-connected, voice-operated (a person's voice, etc.) smart speakers, which enable one to listen to news and music and operate home appliances, are typical examples. Apart from these devices, communications-capable models of conventional household appliances such as air-conditioning units, refrigerators, and TVs are gradually expanding.

In particular, as the accuracy of speech recognition has increased dramatically with advances in AI technology, commercialization of smart speakers has progressed[171] and according to research by the American company eMarketer, the number of smart speaker users in the US in 2017 reached 35.6 million people.[172]

3. Real-world Applications

（1） Factories

---

n," 2017, pp.128-130. <http://www.soumu.go.jp/johotsusintokei/whitepaper/ja/h29/pdf/n3300000.pdf>(in Japanese)

[169] A radio communications system compliant with the IMT-Advanced standard established by the International Telecommunication Union. It is a higher-speed communications standard as compared with the third-generation mobile communications system (3G). NB., LTE is an abbreviation of long-term evolution.

[170] Control boards such as Raspberry Pi and Arduino are known.

[171] Representative examples include Amazon's "Amazon Echo" series and Google's "Google Home" series. See Chapter IV, Voice Interfaces.

[172] "Alexa, Say What?! Voice-Enabled Speaker Usage to Grow Nearly 130% This Year," 2017.5.8. eMarketer Website <https://www.emarketer.com/Article/Alexa-Say-What-Voice-Enabled-Speaker-Usage-Grow-Nearly-130-This-Year/1015812>

In Germany, the "Industrie 4.0"[173] technical policy has been promoted since 2011. This aims to achieve an autonomous, distributed intelligent manufacturing system by networking devices within factories, and combining these with sensors and AI. For example, at Daimler AG, which is adopting Industrie 4.0, network creation is being undertaken in every stage of design and production.[174] The German Research Centre for Artificial Intelligence[175] creates simulated factories within its laboratories, and conducts experiments in collaboration with various companies.[176]

(2) Traffic

Telematic vehicle insurance, linking dash cams, and automobile insurance can be cited as IoT in automobiles. Starting in January 2018 (Heisei 30), Toyota Motor Corporation and Aioi Nissay Dowa Insurance have begun selling insurance with discounts of up to 80% on driving premiums among its insurance fees, based on driving information obtained from vehicles connected to the internet.[177]

Moreover, the American Uber Technologies Inc., which operates a dispatch service, operates a system that changes the route of the ride-sharing service according to past usage and traffic conditions.[178]

(3) Housing

As a representative example of IoT in housing, the American company Nest's[179] (acquired by Google in 2014) thermostat is famous. Nest's thermostat, which uses sensors and AI (machine learning) to automatically control the air-conditioning in homes, can reduce electricity bills by 20% while maintaining comfort. Furthermore, using the data accumulated by these thermostats, electricity suppliers can predict the demand for power, and some of the cost reductions achieved through this system are being passed back to consumers.[180]

The smart locks described before can be cited as another example.[181] In addition to private use, they are used as a means of delivering keys in holiday rental services such as AirBnB, and are

---

173 *supra note* (134)

174 "Production is becoming smart. Industry 4.0 and the networked factory." Daimler Website <https://www.daimler.com/innovation/case/connectivity/industry-4-0.html>

175 "A central research organisation of German AI research, and takes the form of a non-profit limited public-private partnership." Dengel, Andreas (Translated by Koichi Kose), "20 Years of the German Artificial Intelligence Research Centre (DFKI) - A path to success and those who made it possible," Information Processing, Vol. 49 No. 7, 2008.7, pp. 810-817.

176 "SmartFactory Laboratory." Deutschen Forschungszentrum für Künstliche Intelligenz (DFKI) Website <https://www.dfki.de/web/living-labs-de/living-lab-smartfactory>

177 Toyota Motor Corporation, Aioi Nissay Dowa General Insurance Co., Ltd, "Development of Japan's first telematic vehicle insurance reflecting drivers' behaviour for Toyota's connected car," 2017.11.8. Toyota Global Newsroom website <https://newsroom.toyota.co.jp/jp/detail/mail/19575777>; "Tough, Connected Car Insurance," Aioi Nissay Dowa General Insurance website <http://aioinissaydowa-tsunagaru.jp/tough-tsunagaru/> (in Japanese)

178 "ETA Phone Home: How Uber Engineers an Efficient Route," 2015.11.3. Uber Engineering Blog Website <https://eng.uber.com/engineering-an-efficient-route/>

179 Nest Website <https://nest.com/>

180 "Nest's Business Model — Flagship IoT startup aims to collect all data in the domestic space," 2015.8.31. nomad journal website <https://nomad-journal.jp/archives/530>

181 In Japan, "Akerun" and "Qrio" have been commercialised. Akerun website (PhotoSync) <https://akerun.com/>; Qrio website <https://qrio.me/> (in Japanese)

expanding rapidly alongside the expansion of these holiday rental services.[182]

(4) Health and Welfare

IoT devices are being used in elderly care services. In Japan, in serviced accommodation for the elderly, absence detection and fall recognition using AI and sensors are being adopted[183] to prevent the overlooking of falls and simultaneously lower management costs.

Various wearable IoT devices have become popular in the field of personal health information management (personal healthcare). Welfare services supporting walking using activity meters, which measure daily human step-count activity, have already begun[184]; however, in the future, with the diversification and advancement of sensors, it is believed that their use will expand into applications in mental health care and disease prevention.

4. Concerns

In Japan, from past experiences of success focusing on manufacturing, the idea of planning industrial revitalization through "monozukuri" is firm, i.e., there is a tendency to focus on the "T," the things, of IoT. However, services creating new value using data arising from "things" together with AI are necessary.

Moreover, as IoT devices spread to households, privacy issues also frequently arise. From the "Insecam Incident,"[185] where 73,000 units had not had their default password changed, resulting in their cameras being viewable from anywhere in the world, information leaks from teddy bears equipped with IoT functionality,[186] to secret data collection by sex-toy manufacturers,[187] the increasing popularity of IoT devices in households has become a "trojan horse," and cases of private information being distributed are abundant. Therefore, it is important to consider privacy in the usage of IoT devices.

However, overseas, there is a tendency to first attempt to do something, and change the rules when issues arise, whereas in Japan, there is a strong tendency to thoroughly investigate all issues prior to launching services. To not trail behind the West in the development of IoT services for the sake of privacy considerations, a balanced strategy is necessary.

Yutaka Arakawa, Nara Institute of Science and Technology

---

[182] "Gemalto, a smartlock solution where your smartphone can be a key," 2017.6.20., MyNavi News <https://news.mynavi.jp/article/20170620-a062/>

[183] "Launch of a safety confirmation service for elderly housing using ICT," 2017.9.20. Family Net Japan website <http://www.fnj.co.jp/news/pdf/2017/20170920.pdf> (in Japanese)

[184] For example, "Everyone's Health Site 'KENPOS,' Ewel website <https://www.ewel.co.jp/category/service/kenpos/p796/> (in Japanese)

[185] "A Creepy Website Is Streaming From 73,000 Private Security Cameras," 2014.11.6. Gizmodo Website <https://gizmodo.com/a-creepy-website-is-streaming-from-73-000-private-secur-1655653510>

[186] "Cyber kid stuns experts showing toys can be 'weapons'," 2017.5.16. Phys.org Website <https://phys.org/news/2017-05-cyber-kid-stuns-experts-toys.html>

[187] "This sex toy tells the manufacturer every time you use it," *Splinter*, 2016.8.9. <https://splinternews.com/this-sex-toy-tells-the-manufacturer-every-time-you-use-1793861000>

Ⅷ Multi-agent Systems

1. Notable Social Background

Through the widespread application of various information systems together with the development of the internet, huge amount of diverse social data have been produced in the distributed environment so that information systems based on conventional centralized architecture have had difficulties in their operation. Accordingly, distributed manner of constructing information systems had attracted many researchers. Then, researches on multi-agent systems has been a part of main stream of AI research since 1980s[188].

For example, by simulating human society, groups of robots, etc., as groups of multiple agents (multi-agent systems: MAS), each of which is modeling an human, a robots, etc. with small-scale AI program (agent), it is possible to apply MAS to solve various problems.

In multi-agent systems, each agent, having its own diverse characteristics, abilities, and purposes, makes decisions independently at the same time as influencing other agents, cooperating with others to avoid collisions, etc. This not only makes it possible to analyze the nature and behavior of groups considering both the diversity of actual people and robots and their interactions, but can also be of use to the design of methods to control such groups.

Researches on multi-agent systems have progressed with theoretical research at its core, pursuing computational models to simulate the behavior of groups in society. For example, a broad range of research activities has been developed with various societal actions and mechanisms as the target, such as negotiation and cooperation protocols, modeling and analysis of competitive markets, and matching a wide variety of service providers and users. However, the number of theoretical works linking to practical systems has scarcely increased, and it has not attained widespread use as a technology for developing distributed systems.

In recent years, societal implementation of the IoT has advanced rapidly, and by 2020, approximately 30.4 billion IoT devices are predicted to be connected to networks.[189] Algorithmic trading (automated trading using computers) is now being used in the stock markets, and it is becoming realistic that automated vehicles will intermix with human-controlled vehicles in the near future. It is intractable to expect the result of integration of information technologies into society, nor its effect to the whole of society. Therefore, designing human society is expected to become a very hard task.

Multi-agent systems enable us to individually model a wide variety of entities/elements, such as humans, robots, sensors, various information systems, etc., Multi-agent systems enable us to individually model a wide variety of entities/elements, such as humans, robots, sensors, various information systems, etc., and to calculate or analyze their continuous interactions. Hence, the utility of MAS is once again being recognized for modeling increasingly complex societies.

---

188 Initial research on multi-agent systems, called distributed artificial intelligence (DAI), was held in the first distributed intelligence workshop in the US in 1980. Randall Davis, "Report on the Workshop on distributed AI," *SIGART Newsletter*, No. 73, 1980.10, pp. 42-43.

189 Ministry of Internal Affairs and Communications, "2016 Information Communications White Paper," 2016, p. 80. (Figure 2-1-1-1), <http://www.soumu.go.jp/johotsusintokei/whitepaper/ja/h28/pdf/n2100000.pdf>(in Japanese)

2. Technology Trends

（1） Simulation Technology

Modeling complex systems, such as real-life human society, as multi-agent systems by calculating the continuous interactions between agents, the method for performing measurement and analysis of the system's behavior is called "multi-agent social simulation" (MASS). MASS is a powerful technique for reproducing complex social phenomena, and is expected to support the design and validation of new systems, mechanisms, services, etc. in society.

One of the typical application domain for MASS is economics. The "U-Mart Project," [190] begun in 1999 and implemented over more than 10 years, has been actively conducting public experiments both domestically and overseas using virtual artificial markets (U-Mart) constructed based on MASS, as an effort to attempt to design systems for financial markets, and many researchers have participated in the representative artificial market research in Japan. .[191] U-Mart is effective not only for research, but also for obtaining teaching materials for information science and economics, and it is used in instruction at numerous universities and graduate schools.[192]

Rescue ina disaster is another suitable application domain for MASS. In response to the Great Han-Shin Awaji Earthquake, the "RoboCup Rescue"[193] was conceived to foster competition for technologies useful for disaster relief using AI and robotics. Since 2001, an international competition has been held using MASS to simulate rescue activities by firefighters, rescue-team, and rescue robots. Over the course of the competitions, attempts to create disaster prevention plans and to predict disaster damages using multi-agent models have been undertaken, thus improving the technology. This effort has been expanded to competitions using actual robots, and their results are contributing to actual activity support under disasters, such as the development of Quince, a robot sent into the reactor building at Fukushima Daiichi Nuclear Power Plant.[194]

（2） Negotiation Technology

Negotiations are one of the main research areas for multi-agent systems. Research on agent negotiations, defined as "a process of exploratory calculations to identify potential consensuses,"[195] began in the 1990s. At the stage, it has never been used outside the area of theoretical research using multiple agents to solve distributed search problems. Subsequently, with the design of functions representing human's preferences which is to be assigned to agents, and the development of research protocols for multi-issue negotiations, technological development aiming to perform negotiations

---

[190] Hiroshi Deguchi, "Laboratory Creation for Economic Advancement - The Significance of Participant Simulati on in Virtual Markets," Evolutionary Economics Proceedings, Vol. 3, 1999, pp. 251-252 (in Japanese).

[191] Hajime Kita et al. eds., *Realistic Simulation of Financial Markets: Analyzing market behaviors by the third mode of science*, Tokyo: Springer, 2016.

[192] Hajime Kita et al., "Educational Activities of Artificial Market Project U-Mart," Systems, Control, Informatio n, Vol. 49, No. 7, 2005.7, pp. 271-276 (in Japanese), <https://doi.org/10.11509/isciesci.49.7_271>

[193] RoboCup-Rescue Technical Committee et al. eds., (Satoru Tadokoro, supervised by Hiroaki Kitano), "RoboC up-Rescue: Emergency Large-Scale Disaster Relief Challenge," Kyoritsu Publishing, 2000 (in Japanese).

[194] Keiji Nagatani et al., "Emergency response to the nuclear accident at the Fukushima Daiichi Nuclear Power Plants using mobile rescue robots," *Journal of Field Robotics*, Vol. 30 No. 1, 2013.1･2, pp. 44-63.

[195] Nick. R. Jennings et. al., "Automated Negotiation: Prospects, Methods, and Challenges," *Group Decision and Negotiation*, Vol. 12, No. 2, 2003, pp. 58-73.

automatically using these agents as human proxies is now being undertaken.

As an attempt to accelerate the development of negotiation technology using agents, the International Automated Negotiating Agents Competition (ANAC)[196] has been held since 2010 and research and development of agents with efficient strategies under varied negotiating conditions has been facilitated. At ANAC, agents conduct negotiations without knowledge of the other side's information. Although closer to negotiations in the real world, as the negotiation partner's information is insufficient, it is not sufficient to simply adopt strategies based on game theory[197] solution concepts and models. In other words, game theory is useful for the analysis of the nature of negotiation problems such as whether a solution (consensus) or equilibrium point exists, but it is necessary to develop new negotiation technologies with consideration for the elements of game theory that are hard to address, such as the complex preferences of negotiators, uncertainty over information about the negotiation partner, and learning and predicting from the negotiation partner's behavior.[198]

Negotiations at ANAC can be viewed as a type of incomplete information game in which all information about the game is not opened to all participants. Conversely, games such as Shogi and Go, where one can obtain all information about the game including information about the other party, are called complete information games. In recent years, AI has shown better performance than humans in Shogi and Go, and interest has now shifted toward incomplete information games. This trend has also occurred in the multi-agent field and technical applications are progressing, with agent players researched and developed from game theory research beating professional human players at poker,[199] an incomplete information game. Moreover, research and development of agents automatically playing a party game "Werewolf," in which players progress through conversation with other players, and wherein players deceive one another and sometimes persuade and cooperate, has also begun in Japan.[200]

3. Real-world Applications

Not limited to the technical fields above, there is a steady accumulation of the number of cases where the results of theoretical research lead to real-world applications. Here, representative examples of applications and promising areas of application are introduced.

---

[196] "Automated Negotiating Agents Competition (ANAC)." Negotiation Website (Interactive Intelligence Group, Faculty of Electrical Engineering, Mathematics, and Computer Science (EEMCS), Delft University of Technology (TU-Delft)) <http://ii.tudelft.nl/negotiation/index.php/Automated_Negotiating_Agents_Competition_(ANAC)>

[197] "Game theory is a theory studying situations in which multiple decision-making agents (humans and agents) interact with one another in their decision-making. Takahiro Watanabe, "Seminar: Introduction to Game Theory," Nihon Keizai Shinbun Publishing, 2008 (in Japanese).

[198] Tatayuki Ito, "Applications of Multi-Agent Automatic Negotiation Model," Information Processing, Vol. 55 No. 6, 2014.6, pp. 563-571 (in Japanese).

[199] "Carnegie Mellon artificial intelligence victorious in heads-up poker tournament," 2017.2.01. ZDNet Website < https://www.zdnet.com/article/carnegie-melon-artificial-intelligence-victorious-in-heads-up-poker-tournament/>; "How an AI took down four world-class poker pros," 2017.2.10. Engadget Website <https://www.engadget.com/2017/02/10/libratus-ai-poker-winner/>

[200] Daisuke Katagami, Fujio Toriumi, Hirotaka Osawa, Michimasa Inaba, Kosuke Shinoda, Hitoshi Matsubara "Project AI Wolf," Artificial Intelligence, Vol. 30, No. 1, 2015.1, pp.65-73 (in Japanese)

（1） Applications in the Security Field

There are successful examples of improvement of the security of various locations by applying game theory for modeling negotiations and cooperation among people.

When designing security plans, it is necessary to solve the difficult issue of how to position limited numbers of security guards while factoring in the actions of attackers targeting poor security. Professor Milind Tambe of the University of Southern California in the US proposed an algorithm to calculate security behavior that incorporates randomness to prevent security plans being predicted by attackers, while considering the differences in the importance of security targets. The "ARMOR" system for determining the patrol routes of security guards and dogs at Los Angeles International Airport has been developed and adopted based on this research.[201]

This algorithm has been utilized for security at various locations, including for the flight scheduling system "IRIS"[202] at the Federal Aviation Security Bureau and the "Protect"[203] system, which determines the patrol routes of the US Coast Guard.

（2） Applications in the Medical Field

Matching, which appropriately determines the combination of providers and beneficiaries of a given service, is one of the primary fields of multi-agent research. There is a case where the developed theory was applied to the development of an algorithm for organ transplantation.

In the US, over 70,000 kidney disease patients are waiting for a transplant, and only 10,000 patients will undergo transplant surgery each year; 4,000 patients will lose their lives. Professor Tuomas Sandholm of Carnegie Mellon University in the US developed a high-efficiency algorithm matching kidney donors to kidney disease patients based on the proximity of hospitals, and in 2008, it was adopted into the Pan-American United Network for Organ Sharing.[204] Since 2010, this algorithm has been in continuous use, automatically generating plans for kidney transplants. For example, it has been reported that it produced and executed a particularly long organ transplant plan involving 60 donors and recipients.[205,206]

---

[201] Marc Ballon, "A Safer World," 2015 Spring. USC Viterbi Website <http://magazine.viterbi.usc.edu/spring-2015-2/features/a-safer-world/>; James Pita et al., "Deployed ARMOR Protection: The Application of a Game Theoretic Model for Security at the Los Angeles International Airport," *Proceedings of the 7th international joint conference on Autonomous agents and multiagent systems: industrial track*, 2008, pp. 125-132. <http://teamcore.usc.edu/papers/2008/AAMASind2008Final.pdf>

[202] Jason Tsai et al., "IRIS - A Tool for Strategic Security Allocation in Transportation Networks," *Proceedings of 8th International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS-2009)*, 2009.5. <http://teamcore.usc.edu/kiekintveld/papers/2009/trkot-IRIS.pdf>

[203] Eric Shieh et al., "PROTECT: An Application of Computational Game Theory for the Security of the Ports of the United States," *Proceedings of 26th AAAI Conference on Artificial Intelligence (AAAI-2012)*, pp. 2173-2179, 2012. <http://teamcore.usc.edu/people/eshieh/shieh_protect_aaai_talk_20120414.pdf>

[204] David J. Abraham, et. al., "Clearing Algorithms for Barter Exchange Markets: Enabling Nationwide Kidney Exchanges," *Proceedings of the 8th ACM Conference on Electronic Commerce (EC-07)*, 2007, pp. 295-304. < https://www.cs.cmu.edu/~sandholm/kidneyExchange.EC07.withGrantInfo.pdf>

[205] Website（The New York Times）< http://www.nytimes.com/2012/02/19/health/lives-forever-linked-through-kidney-transplant-chain-124.html>, "60 Lives, 30 Kidneys, All Linked", 2012.2.18

[206] Website（The New York Times）<http://www.nytimes.com/interactive/2012/02/18/health/record-chain-of-kidney-transplants.html?action=click&contentCollection=Health&module=RelatedCoverage&region=Marginalia&pgtype=article>, "A Record Chain of Kidney Transplants", 2012.2.18

（3） Promising Areas of Application

As already stated, in recent years, implementation of IoT within society has advanced rapidly. Future social systems are becoming more complex, and their design is becoming more difficult. MASS, which predicts and analyzes the behavior of complex systems, is a promising technology for supporting the design of these complex social systems. In Japan, in the 2009 Transdisciplinary Science and Technology Roadmap produced by the Transdisciplinary Federation of Science and Technology,[207] the expectations for the usefulness of MASS in the design of social systems were described.[208] This trend is gaining momentum through the use of Big Data and high-performance computing, and the following budding attempts have begun.

Professor Kiyoshi Izumi of the University of Tokyo is undertaking systems design for economic markets using artificial market simulation with multiple agents. There are ongoing attempts to extract knowledge related to market design through wide-scale analysis of the influence of changes in tick size (minimum units of price fluctuation) on the Tokyo Stock Exchange using MASS, and to establish how to protect the market share (or conversely, acquire) in the face of competition between domestic and foreign stock markets.[209]

In the transportation field, in the design of transport systems using MASS, future ride-sharing companies will combine the advantages of taxis (demand type) and route buses (shared transport), and a system of vehicle operation "smart access vehicle," (SAV),[210] which can operate vehicles along optimal routes in response to the demand communicated between the customer and driver, is being developed. SAV technology is based on the MASS developed by Dr. Itsuki Noda at the National Institute of Advanced Industrial Science and Technology to verify the effects of the introduction of on-demand buses.[211] A good example arising from the actual development and operation of a system is validating the feature requirements of new traffic systems in advance using MASS, and it is believed that similar attempts can be applied to fields outside of traffic.

4. Future Issues

Multi-agent research is not expected to remain theoretical, but to continue to contribute to the construction of new social mechanisms, and cases of development accompanying these practical efforts are expected to increase. In such a case, the issue becomes how to model the actual society targeted for support. In other words, we confront the issues of agent modeling, i.e., with what granularity the detail of each agent should be modeled, and whether the solutions and predictions obtained from the multi-agent system have practical meaning. For this problem, how to secure a

---

[207] Union of academic societies specialising in general science and technology applicable in transdisciplinary fiel ds（Designated Non-Profit Organisation）

[208] Transdisciplinary Federation of Science and Technology "Transdisciplinary Science and Technology Academic Road Map Report" 2009.3, pp. 94-95. (in Japanese) <http://www.meti.go.jp/policy/economy/gijutsu_kakushin/k enkyu_kaihatu/20fy-pj/oudan2.pdf>

[209] Takanobu Mizuta et al., "Relationship analysis of tick size and transaction volume in stock markets using ar tificial market simulation," JPX Working Paper, Vol. 2, 2013.1.30. (in Japanese) Japan Exchange Group webs ite <http://www.jpx.co.jp/corporate/research-study/working-paper/tvdivq0000008q5y-att/JPXWorkingPaperVol2.pdf>

[210] "SAV（Smart Access Vehicle）" (in Japanese) Mirai Share website <http://www.miraishare.co.jp/sav/>

[211] Noda Itsuki et al., "Do On-Demand Buses Pay?" IECIE Technology Research Report, Vol. 2003 No. 8, 200 3.1.29, pp. 31-36. (in Japanese)

sufficient amount of data related to the human behavior to be modeled (or group thereof), and how to learn about human behavior from the data, are the keys to the development of technology related to data collection and learning.

Hiromitsu Hattori, Ritsumeikan University

IX Crowdsourcing

1. Notable Social Background

Crowdsourcing is a general term for the mechanism of making requests of an unspecified number of people for work, and an online platform to realize it. The presence of compensation for crowdsourcing work varies; however, Amazon's crowdsourcing platform, Mechanical Turk (MTurk), has prompted attention toward crowdsourcing.[212] Using MTurk, clients can easily outsource simple tasks, and workers can receive compensation working entirely online. MTurk has achieved growth as a platform that can capture a large workforce, and many similar platforms have appeared both in Japan and overseas.

To imitate human judgment, AI technology requires correct answer data created by humans. For example, to build an algorithm to determine whether a dog or a cat is depicted in a picture, "pictures of dogs" and "pictures of cats" as classified by humans are necessary. Crowdsourcing has been widely used as a method for expanding the scale of this kind of work by adding meaning to data. Furthermore, to use AI technology in solving social problems, cooperation with human knowledge, perception, judgments, and decision-making is indispensable. The concept of "human computation" has been proposed, incorporating human queries into AI systems, and crowdsourcing is garnering attention as the basis for achieving this purpose.

2. Technology Trends

Here, basic technological trends for improving the usability of crowdsourcing, quality control, workflow control, and mechanism design are discussed.[213]

(1) Quality Control

Unlike conventional forms of employment in which employers and workers can establish ongoing relationships of trust, it can be difficult for employers to gauge the ability, reliability, motivations etc., of workers when crowdsourcing, and hence, quality control of the output of such work is an important issue. As a countermeasure, a method called "redundancy" is often used, i.e., requesting the same work from multiple people to ensure quality. Studies into statistical machine learning methods to estimate the reliability of each worker and the degree of difficulty of each task in such cases are ongoing.

---

[212] Amazon Mechanical Turk Website <https://www.mturk.com/>

[213] This article refers to Hisashi Kashima et al., "Human computation and Crowd Sourcing" (Machine Learning Professional Series) Kodonsha, 2016, pp.24-68 (in Japanese)

（2） Workflow Control

In crowdsourcing, it is possible to combine multiple tasks, such as handling the results of one task in another. Using this, workflows in which the output by a worker is evaluated and corrected by another worker are being studied.

（3） Mechanism Design

To improve the speed and quality assurance of work in crowdsourcing, the participation of workers having the ability and motivation to carry out the task is indispensable. To encourage the participation of such workers, research is being undertaken into "mechanism design," i.e., setting the contents of tasks and compensation appropriately. For example, a method of preventing the involvement of dishonest workers by splitting compensation into a participation fee and a performance fee has been proposed.

3. Real-world Applications

（1） Examples of Real-world Applications

（i） Large-scale Character Recognition

Large-scale character recognition is an important application example, having been undertaken since the early stages of crowdsourcing. To get humans to confirm images of characters that AI recognition found difficult, Luis von Ahn, associate professor at Carnegie Mellon University developed the "reCAPTCHA" system, using crowdsourcing to achieve a high degree of accuracy in character recognition when digitizing the contents of books.[214] When determining whether a user accessing a website is human or a computer program attempting unauthorized access, a character recognition test is given to the user. reCAPTCHA can have that user perform character recognition work by including images of characters from books in the test.

Large-scale character recognition through crowdsourcing is also used in industry. For example, Sansan, which provides a service converting business cards to digital forms, uses crowdsourcing for character recognition of those business cards.[215]

（ii） Large-scale Annotation

Image, voice, and video data are created and stored in large quantities on a daily basis. To efficiently classify and organize this enormous amount of data, in addition to making it easy to search, adding annotations to the data is essential.[216] Large-scale annotation through crowdsourcing is also contributing to AI development.

For example, Associate Professor Fei-Fei Li of Stanford University produced annotations for over 10 million images using crowdsourcing, publishing it as the "ImageNet" dataset.[217] At an image

[214] Luis von Ahn et al., "reCAPTCHA: Human-Based Character Recognition via Web Security Measures," *Science*, Vol.321 Issue 5895, 2008.9.12, pp.1465-1468.

[215] "Data Strategy & Operation Center" Sansan Inc. website <https://jp.corp-sansan.com/dsoc/> (in Japanese)

[216] To add annotations (metadata) to data such as images, voice and video etc.

[217] Jia Deng et al., "ImageNet: A Large-scale Hierarchical Image Database," *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, 2009, pp. 248-255.

recognition competition held in 2012, an image recognition method applying deep learning to the Image Net image data achieved a high level of accuracy, and catalyzed the subsequent deep learning boom.

（iii） Real-time Applications

Real-time applications (applications processing tasks in real time) incorporating crowdsourcing are being developed. Associate Professor Jeffrey P. Bigham of Carnegie Mellon University developed a smartphone application, "VizWiz," to support the visually impaired.[218] For example, when "I want to select a can from a cupboard filled with cans," the visually impaired person takes a picture of the cupboard with cans and simultaneously records the spoken question in the smartphone; the image and speech data are sent to VizWiz and an answer is returned in tens of seconds. The creation of an answer according to the photo and question is performed by crowdsourcing workers. As a visually impaired person's question is automatically sent to numerous workers, the question and answer process is performed in nearly real time. It is an example of a real-time question and answer task applied to image and speech performed through crowdsourcing, a difficult task for artificial intelligence today.

(2) Promising Areas of Application

(i) Translation, Dialog, and Q&As

It is currently difficult for language processing technology to perform all translation, dialog, and Q&A tasks. Therefore, efficient project advancement through the division of work into projects that can be achieved using language processing technology, and work that cannot be performed except by people, thereafter using division of labor to crowdsource the latter, is being investigated.[219]

Moreover, depending on the contents of the translation, dialog, or Q&A, expertise of the worker may be required. In such cases, using the quality assurance technology described above, it may be possible to predict the expertise and reliability of the worker, and to choose workers appropriate for the project accordingly.

（ii） Gathering Ideas for Problem-solving

There are already practical examples of the use of crowdsourcing to collect ideas for problem-solving, which can be considered gathering the collective wisdom of mankind. For example, the US DARPA has designed military vehicles through crowdsourcing.[220] In addition, the "InnoCentive" platform, which collects ideas to solve issues in research and development, is being used by P&G

[218] Jeffrey P. Bigham et al., "VizWiz: Nearly Real-time Answers to Visual Questions," *Proceedings of the 23rd annual ACM Symposium on User Interface Software and Technology*, 2010, pp. 333-342. <http://up.csail.mit.edu/other-pubs/vizwiz.pdf>

[219] Atsushi Nakada, "Using Machine and Human Specialisation in Division of Labour in Translation" 2016.1.5. Nikkei Business Online <http://business.nikkeibp.co.jp/atcl/report/15/061700004/122100063/> (in Japanese)

[220] "After Successful Design Challenge Competition and Testing, DARPA Begins Early Transition of Adaptive Vehicle Make Technologies," 2014.2.5. Defense Advanced Research Projects Agency website <https://www.darpa.mil/news-events/2014-02-05>

America, etc.[221]

In the future, it is expected that problem-solving through crowdsourcing will be applied to a wide range of fields, through the brainstorming of ideas and the development of technologies related to the process of efficiently evaluating and refining ideas.

（iii）Employing the Elderly

Crowdsourcing, which makes it possible to work at home, is suitable for elderly people who are motivated to work. However, it is necessary to assume that there are limitations on the amount of time and work that can be handled owing to physical restrictions among the elderly. Therefore, techniques are being studied to enable multiple elderly people to work as virtual teams through crowdsourcing.

Professor Michitaka Hirose of Tokyo University, collaborating with IBM Japan, is advancing research on the concept of the "Senior Cloud." This method performs matching based on the experience and skill of the elderly to specific projects, and when multiple elderly people work as a virtual team, it realizes efficient matching and schedule organization.[222]

4. Future Issues

As the use of crowdsourcing is advanced, there are concerns as to whether operators may move toward exploitation with unfairly low wages. For example, it can be pointed out that labor exploitation might arise from economic disparities in the crowdsourcing market.[223] This issue can be said to be disadvantageous not only for workers, but also for employers owing to long-term deterioration in the quality of work and decrease in the number of participants. In response to this issue, improvements in the relative standing of workers by introducing a mechanism for the mutual evaluation of employers and workers, and by sharing information about workers on multiple platforms, etc., are being considered as a solution.

Yukino Baba, Kyoto University

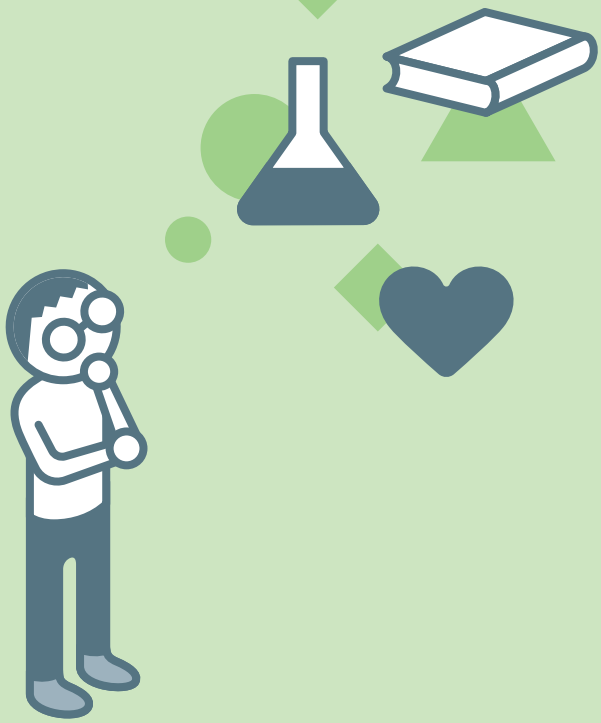
[221] Jeff Howe "*Crowdsourcing - Why the Power of the Crowd Is Driving the Future of Business*," Crown Business, 2008.

[222] Research and Development of the "Senior Cloud," website <http://sc.cyber.t.u-tokyo.ac.jp>

[223] Rowland Manthorpe, "Gig Economy, the actual situation that is causing "a new type of poverty: investigation results," *WIRED*, 2017.4.4 <https://wired.jp/2017/04/04/gig-economy-jobs-benefits-dangers/>

Part 2

AI Trends by Domain



Part 2: AI Trends by Domain

[Overview]

AI and robotics are currently used in various domains. Part 2 introduces cases primarily in Japan in eight different domains, where AI and robotics are introduced in many organizations—that is, healthcare, elderly care, art and design, education, hospitality, transportation and mobility, agriculture, and public order and security. This part also introduces how AI is used for military purposes overseas and in the world of *shōgi* (Japanese chess) in the column section. Introducing actual cases in which AI and robotics have already been adopted provides insight for other areas in which AI and robotics will prevail in the future.

In this report, we focus on the employment and labor of "experts" by using AI and robotics as tools. Therefore, we make only minimal reference to end users, such as patients and consumers. The experts discussed in Part 2 are, in concrete terms, doctors, care workers (however, we need to keep in mind that family members bear quite a few roles), creators, teachers, those who work in the service industry, drivers, farmers, police officers and security guards, soldiers, and *shōgi* players. Bearing in mind that AI will be used in various fields in the future, the report sorts out how experts in different fields are using AI and robot technologies that are beginning to prevail in their workplaces.

This report adopts the perspective that technologies are used within interactions with context or needs, such as social issues. In Part 2, therefore, each chapter (1) describes the background information, such as issues facing each domain in Japan, social and industrial structures, and philosophies; (2) discusses that there are institutional and social measures against these issues, in addition to technological measures, and (3) introduces the actual cases in which AI, robotics, and ICT are used, instead of describing how technologies are used. Finally, each chapter sorts out the points of argument, such as legal, social, and ethical issues arising from the interaction between technology and society, and introduce issues that are difficult to solve only with technology.

I Healthcare

1. Policy issues in the domain of healthcare

Population aging and birthrate declines are progressing more rapidly in Japan compared with other countries in the world. According to the National Institute of Population and Social Society Research, the total population is decreasing, while the rate of population aging keeps increasing; indeed, about one of four people in Japan is estimated to be an elderly person aged 75 or older.[1] According to the Ministry of Health,

* The last date of access to the internet information in this paper is May 1, 2018.

[1] National Institute of Population and Social Society Research, Population Projection for Japan: 2016 to 2065 (Institute of Population Problems research series Vol.336), 2017.7.31, p.230. <http://www.ipss.go.jp/pp-zenkoku/j/zenkoku2017/pp29_ReportALL.pdf>. (in Japanese).

Labour and Welfare, the national health expenditure was 42 trillion yen (estimated amount) in 2015 and has increased every year since then,[2] and it is expected to reach 61 trillion yen in 2025.[3]

Underlying this increase in healthcare expenditure is the increase in the average life expectancy due to recent advancements in medical technologies (particularly acute-phase treatment) and changes in the disease structure—that is, the increase in the number of three major mortal diseases,[4] malignant neoplasm (cancer), heart disease, and cerebrovascular disease, and the increase in the number of chronic diseases, mainly diabetes. These diseases not only take away life but also often cause a decline in physical functions and quality of life. It has been noted that the development and progress of these diseases are associated with lifestyle habits, including dietary habits, fitness habits, alcohol consumption, smoking, and stress. Therefore, promoting efforts to improve lifestyle habits on a continuous basis and to improve health is an effective means to prevent them.[5]

To support the super-aged society, we should secure healthcare professionals, maintain the quality of medical care, and provide efficient medical services. On the other hand, expectations are placed on the industries associated with the "extension of healthy life expectancy," including healthcare and elderly care industries, as growing industries. In the "New Growth Strategy" (Cabinet decision on June 18, 2010), the healthcare industry, elderly care industry, and health-related industry are positioned as industries driving growth in Japan. A plan was also announced to establish a system or framework to provide various products and services while ensuring safety and improving quality in order to encourage the private sector to enter into these industries, with the goal of creating a market worth about 50 trillion yen and generating 2.84 million new jobs by 2020.[6]"Growth Strategy 2017" (Cabinet decision on June 9, 2017) addresses the "extension of healthy life expectancy" as one of the five areas on which the national government has focused policy resources, aiming to "substantially improve quality and reduce burdens of doctors and patients" through the use of telemedicine and telecare as well as artificial intelligence (AI).[7]

2. Ensuring the availability healthcare professionals and the use AI and robotics

(1) Ensuring the availability of medical care professionals and work style reform

An excess of doctors was noted as one of the factors causing an increase in medical care expenditure in the 1980s.[8] Therefore, measures were taken to reduce the number of university medical students. An

---

[2] Ministry of Health, Labour and Welfare, "Summary of the National Medical Care Expenditure in 2015," 2017.9.13, p.12. <http://www.mhlw.go.jp/toukei/saikin/hw/k-iryohi/15/dl/data.pdf>. (in Japanese).

[3] For example, General Affairs Division, Health Insurance Bureau, Ministry of Health, Labour and Welfare, "About Medical Insurance Reform," 2015.6.19, p.4. <http://www.mhlw.go.jp/file/06-Seisakujouhou-12600000-Seisakutoukatsukan/0000089357.pdf>. (in Japanese).According to National Federation of Health Insurance Societies, "Estimation of National Medical Care Expenditures toward 2025," 2017.9, p.2. <http://www.kenporen.com/include/press/2017/20170925_1.pdf> (in Japanese). it is estimated to be 57.8 trillion yen.

[4] Of these, the number of deaths from cerebrovascular disease per population in Japan is decreasing due to advancements in acute-phase treatment, but there are many patients suffering from the disease as a chronic disease. Therefore, its medical cost expenditure remained high at about 1.8 trillion yen in 2015 (Ministry of Health, Labour and Welfare, *op.cit*. (2), p.19).

[5] Many epidemiological studies are being conducted globally, including Kyushu University in Hisayama-cho, Fukuoka Prefecture, "Hisayama Study." < http://www.epi.umn.edu/cvdepi/study-synopsis/hisayama-study/>.

[6] "New Growth Strategy: Blueprint for Revitalizing Japan," (Cabinet decision on June 18, 2010), p.23-25. Office of the Prime Minister website < https://japan.kantei.go.jp/kan/topics/sinseichou01_e.pdf>

[7] "Growth Strategy 2017" (Cabinet decision on June 9, 2017), p.13. Ministry of Foreign Affairs of Japan website < http://www.mofa.go.jp/files/000272312.pdf >.

[8] Hitoshi Yoshimura, "My view on situations surrounding medical care expenditure and measures taken," *Social Security Review*, No.1424, 1983.3.11, p.13. (in Japanese).

appropriate allocation of doctors was also discussed back then, but doctors are now often overworked.[9] Doctors work extremely long hours and have a duty to provide treatment.[10] However, it is also difficult to distinguish labor from training,[11] and it is therefore necessary to establish an environment in which they can continue learning though on the on-the-job training (OJT). This is a work practice that forces self-sacrifice and creates uncertainty regarding a future career. Some note that medical treatment has been assured through the self-sacrifice of healthcare professionals, including doctors, nurses, and other medical staff.[12]

Under these circumstances, measures were taken against the shortage of doctors and an uneven distribution of doctors. Specifically, the number of students accepted to medical schools was increased,[13] with the establishment of a framework to accept students from the same prefecture. In addition, new medical departments were established,[14] which had been discouraged for many years. Team medicine[15] has also been promoted through an expansion of the work scope of nurses and staff other than doctors. In 2015, the government began promoting the development of nurses[16] who could provide some assistance in medical care (for example, IVs to those who are in a state of dehydration (by judging the level of dehydration and making corrections via transfusion)) using procedure manuals without waiting for the judgment of doctors or dentists. The government is also looking into reforming work styles based on the actual work situation[17] of healthcare professionals.[18]

---

[9] There have been incidents and lawsuits associated with overworking doctors, including a trainee doctor at Kansai Medical University (1998), a pediatrician in Tokyo (1999), a trainee doctor of gynecology and obstetrics in Tokyo (2015), and a trainee doctor at Niigata City General Hospital.

[10] "No medical practitioner who provides medical treatment shall refuse any request for examination or treatment without just cause." Medical Practitioners' Act (Act No. 201 of 1948), Article 19 (1).

[11] It has been held that "trainee doctors are workers as well," pertaining to the overwork death of a trainee doctor at Kansai Medical University in 1998. Decision by the Second Petty Bench of the Supreme Court, Supreme Court Reports (civil cases), Volume 59, No. 5, p.938. (in Japanese).

[12] Committee for examining future work practices of doctors and nurses based on new medical practices, "Report of the Committee for examining future work practices of doctors and nurses based on new medical practices," 2017.4.6, p.4, 11. Ministry of Health, Labour and Welfare Website <http://www.mhlw.go.jp/file/05-Shingikai-10801000-Iseikyoku-Soumuka/0000161081.pdf>. (in Japanese). There have been deaths of nurses from overwork, such as at National Cardiovascular Center (2001) and Tokyo Saieseikai Central Hospital (2007).

[13] Ministry of Education, Culture, Sports, Science and Technology, "About increase of the prescribed number of medical students in 2018," 2017.10.16. Ministry of Education, Culture, Sports, Science and Technology Website <http://www.mext.go.jp/component/b_menu/shingi/toushin/__icsFiles/afieldfile/2017/10/16/1397261_2_1.pdf>. (in Japanese).

[14] In 2016, the Faculty of Medicine was established at Tohoku Medical and Pharmaceutical University as the first department of medicine that was newly established for the first time in 38 years. In 2017, the Faculty of Medicine was established at the International University of Health and Welfare.

[15] Various healthcare professionals engaging in medical care share goals and information, divide tasks but cooperate with and complement each other, and provide medical care appropriate for the situation of each patient, assuming that they are highly skilled. Ministry of Health, Labour and Welfare, "About promotion of team medicine (Report of the committee for investigating promotion of team medicine)," 2010.3.19. <http://www.mhlw.go.jp/shingi/2010/03/dl/s0319-9a.pdf>. (in Japanese).

[16] "Summary of the nurse training system to perform specific tasks," Ministry of Health, Labour and Welfare Website <http://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000070423.html>. (in Japanese).

[17] Ministry of Health Labour and Welfare, Special research "Survey of doctors' working conditions and their opinions on work styles," Research Group & Health Policy Bureau, "Survey of doctors' working conditions and their opinions on work styles," 2017.4.6. <http://www.mhlw.go.jp/file/05-Shingikai-10801000-Iseikyoku-Soumuka/0000163402.pdf>. (in Japanese). In addition, demand-supply estimations of doctors, nurses, physical therapists, and occupational therapists are discussed at the "Committee for investigating demand-supply of healthcare professionals," Ministry of Health Labour and Welfare Website, http://www.mhlw.go.jp/stf/shingi/other-isei.html?tid=315093>. (in Japanese).

[18] "Committee for investigating work style reform of doctors," same as above <http://www.mhlw.go.jp/stf/shingi/other-isei.html?tid=469190> (in Japanese).; "Social Security Council (subpanel on medical insurance)," same as above <http://www.mhlw.go.jp/stf/shingi/shingi-hosho.html?tid=126706> (in Japanese).; Fumi Tsutsui, "Work style reform of doctors proposed by freelance doctor," Shuzo Nishimura (ed.), *White Paper on Healthcare: 2017-2018*, Japan Medical Planning, 2017, pp.145-153. (in Japanese).

(2) Discussions on the use of AI and robotics in the domain of healthcare

In terms of the use of AI and robotics in the domain of medicine, various possible applications have been debated along with the progress of medical informatization. Examples include assisting information gathered during medical interviews and tests, diagnosis based on gathered information and its assistance, planning treatment programs (including genomic medicine), implementation of treatment (including robots), drug discovery, improvement of the quality of medical care, streamlining of medical care, reductions of work burdens, generation of new medical knowledge (e.g., disease concepts), prevention and early detection, and monitoring dementia patients.

On the other hand, some voiced strong objections to the introduction of computers in medicine in the 1970s, because they would take away doctors' jobs.[19] For instance, developed by Stanford University, "Mycin," which is an attempt to apply an expert system[20] developed in the 1970s to medicine, is a device for diagnosing contagious blood diseases and presenting recommended drug treatment. While it showed better results than non-specialist doctors,[21] it was not put to practical use due to ethical and legal issues (e.g., liability in the event of an error).[22]

To improve the quality of medical care, reduce burdens on the medical front, and streamline medical processes, expectations have been placed on information and communication technology (ICT), including AI.[23] Especially due to advancements in technologies, such as deep learning, possibilities for utilizing AI in the medical field are growing. The Ministry of Health, Labour and Welfare's Panel for AI Utilization in Healthcare presented a policy to promote AI development in the six priority areas, "diagnostic imaging support," "drug discovery," "surgery support," "genomic medicine," "diagnosis and treatment support," and "elderly care and dementia."[24] The ministry's committee for examining the future work practices of doctors and nurses based on new medical practices has also encouraged the promotion of technological innovation that can be utilized on the medical front, such as the adoption of technology such as deep learning in medical care, high-accuracy diagnostic imaging using AI, and practical application of patient-watching robots using sensor technology.[25]

---

[19] "Healthcare Information Systems," 2016.4.7, pp.6-7. Graduate School of Medicine and Faculty of Medicine, The University of Tokyo website <http://www.m.u-tokyo.ac.jp/medinfo/wp-content/uploads/2014/10/SPH2016-04-07handoutUP1.pdf>. (in Japanese).

[20] AI system that makes computers memorize experts' knowledge and have them make inferences or solve problems based on it.

[21] Bruce G. Buchanan and Edward H. Shortliffe, *Rule Based Expert Systems: The MYCIN Experiments of the Stanford Heuristic Programming Project*, Reading, MA: Addison-Wesley, 1984, pp.592-593.

[22] See Randolph A. Miller et al., "Ethical and Legal Issues Related to the Use of Computer Programs in Clinical Medicine," *Annals of Internal Medicine*, Vol.102 No.4, 1985.4, pp.529-536 for ethical and legal issues as of 1985 regarding the clinical use of similar computer programs.

[23] Panel for ICT Utilization in Healthcare, "Toward establishment of 'next-generation healthcare system' using ICT – 'Create' 'connect' and 'open' data," 2016.10.19. Ministry of Health, Labour and Welfare website <http://www.mhlw.go.jp/file/05-Shingikai-12601000-Seisakutoukatsukan-Sanjikanshitsu_Shakaihoshoutantou/0000140306.pdf>. (in Japanese).

[24] Panel for AI Utilization in Healthcare, "Report of the Panel for AI Utilization in Healthcare," 2017.6.27. Ministry of Health, Labour and Welfare Website <http://www.mhlw.go.jp/file/05-Shingikai-10601000-Daijinkanboukouseikagakuka-Kouseikagakuka/0000169230.pdf>. (in Japanese).

[25] Committee for examining future work practices of doctors and nurses based on new medical practices, *op.cit.* (12), p.39.

3. Cases

Hereinafter, this chapter will go over how AI and robotics are utilized in "diagnostic imaging support," "genomic medicine," "diagnosis and treatment support," and "surgery support" among the six priority areas, how they affect work styles, and what kind of issues arise.[26]

(1) Diagnostic imaging support

The use of deep learning is highly anticipated in the field of diagnostic imaging support. It is now clinically used in areas such as radiology, pathology, dermatology, ophthalmology, and endoscopy.[27] The Japan Agency for Medical Research and Development (AMED) has implemented a project for developing image databases in academic societies of various domains and promoting their use through AI.[28]

Traditionally, doctors look at these images themselves to make diagnostic judgments, but with the use of AI, many of these tasks of doctors will probably be replaced. However, accuracy above a certain level is required of AI to prevent liability from arising from such judgments. Therefore, AI will be utilized for a limited purpose under the responsibility of doctors—that is, for diagnosis support for the time being.[29] Yet, AI has achieved the same level of judgment as regular doctors or even higher.[30] Therefore, some note that "AI won't replace doctors, but doctors not using AI will be replaced by doctors using AI."[31]

---

[26] See "II Elderly Care" for "elderly care and dementia." This paper will not discuss in detail "drug discovery" because employment and labor issues arising from the use of AI and robotics are subtle in this area (drug discovery using AI and robotics is anticipated as part of "genomic medicine.") Other than the priority areas, AI can be utilized to formulate medical policies, streamline people's flow within hospitals, and streamline operations. Some are cautious about the use of AI in public areas (for example, Julia Powles and Hal Hodson, "Google DeepMind and healthcare in an age of algorithms," *Health and Technology*, Vol.7 No.4, 2017.12, pp.351-367. <https://link.springer.com/content/pdf/10.1007%2Fs12553-017-0179-1.pdf>).

[27] Research cases include the following: Varun Gulshan et al., "Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs," *JAMA*, Vol.316 No.22, 2016.12.13, pp.2402-2410. <https://jamanetwork.com/journals/jama/fullarticle/2588763>; Andre Esteva et al., "Dermatologist-level classification of skin cancer with deep neural networks," *Nature*, Vol.542(7639), 2017.1.25, pp.115-118; Daniel Shu Wei Ting et al., "Development and Validation of a Deep Learning System for Diabetic Retinopathy and Related Eye Diseases Using Retinal Images From Multiethnic Populations With Diabetes," *JAMA*, Vol.318 No.22, 2017.12.12, pp.2211-2223; Satoki Shichijo et al., "Application of Convolutional Neural Networks in the Diagnosis of Helicobacter pylori Infection Based on Endoscopic Images," *EBioMedicine*, Vol.25, pp.106-111; Neeraj Kumar et al., "A Dataset and a Technique for Generalized Nuclear Segmentation for Computational Pathology," *IEEE Transactions on Medical Imaging*, Vol.36 No.7, 2017.7, pp.1550-1560; Babak Ehteshami Bejnordi et al., "Diagnostic Assessment of Deep Learning Algorithms for Detection of Lymph Node Metastases in Women With Breast Cancer," *JAMA*, Vol.318 No.22, 2017.12.12, pp.2199–2210. There also efforts in the private sector, including Enlitic <https://www.enlitic.com/>,Arterys <https://arterys.com/>, Infervision <http://www.infervision.com/infer-en>, and NVIDIA <http://www.nvidia.com/>. There are also articles on the use of AI in endoscopy, including Junichi Oshita, "Is it true endoscope is getting smarter with AI ?" 2017.9.25. Nikkei Technology Online Website <http://techon.nikkeibp.co.jp/atcl/feature/15/030200065/092100010/>. (in Japanese).

[28] Image databases are being built at Japan Radiological Society, Japanese Society of Pathology, Japan Gastroenterological Endoscopy Society, and Japanese Ophthalmological Society. Makoto Suematsu, "Efforts and Issues of the Japan Agency for Medical Research and Development (collection of attachments) (3rd Council of Research and Management 2017 (November 8, 2017) Material 1-2), 2017.11.8, pp.30-31. <https://www.amed.go.jp/content/000024495.pdf>. (in Japanese).As part of the same study, "Research Center for Medical Big Data" was created within the National Institute of Informatics (NII) to establish cloud platforms to collect medical imaging big data using an academic information network created and operated by NII called "SINET5" and to conduct research and development of medical image analysis systems using AI technology. "NII launches new Research Center for Medical Big Data/FDesigning cloud platforms to collect medical imaging data and developing image analysis technology using AI," 2017.12.25. National Institute of Informatics website < https://www.nii.ac.jp/en/news/release/2017/1225.html>.

[29] Panel for AI Utilization in Healthcare, *op.cit.* (24), p.29. This concerns only the use of AI in general medical practices and is not limited to diagnostic imaging support.

[30] Esteva et al. has demonstrated the accuracy of the specialist doctor level in terms of the identification of skin cancers using AI (Esteva et al., *op.cit.*(27)). Bejnordi et al. reports accuracy above the level of doctors in terms of the detection of breast cancer metastasis (Bejnordi et al., *op.cit.*(27)).

[31] Statement from Curtis Langlotz of Stanford University at the meeting of the Radiological Society of North America (RSNA). Shaun Sutner, "Radiology AI and deep learning take over RSNA 2017," 2017.11.28. TechTarget SearchHealthIT Website <http://searchhealthit.techtarget.com/news/450430826/Radiology-AI-and-deep-learning-take-over-RSNA-2017>.

Trust from experts on programs using AI was considered an issue with "Mycin" mentioned earlier. However, trust is expected to increase when the accuracy of AI increases. Vast volumes of data are nonetheless necessary to gather and analyze imaging data for learning. Such data are usually gathered without assuming the use in the development process of programs using AI. Therefore, there is an issue of how to obtain consent from individuals from the perspective of the protection of personal information. In addition, the accuracy of these programs using AI keeps changing along with learning, and the decision-making process may turn into a so-called "blackbox." Therefore, there is also an issue of how they should be evaluated as medical equipment.[32]

(2) Genomic medicine

In terms of the use of AI in genomic-based drug discovery and precision medicine,[33] there are several cases in Japan and overseas, such as the use of IBM's AI called "Watson"[34] at the Institute of Medical Science, University of Tokyo.[35] In these cases, AI is applied to data that cannot be handled by people alone—that is, data of piles of academic papers and biomolecule information such as genomes and epigenomes.[36] Therefore, such AI probably will not take away jobs, but it may influence work styles by significantly changing the positions of tests, for instance.

It was reported by media that "AI made a diagnosis" at the Institute of Medical Science, University of Tokyo, but the final judgment was actually made by a doctor. Therefore, it is not so different from evidence-based medicine (EBM)[37] at least for now. As in this case, when using AI for efficiently analyzing vast

---

[32] The "21st Century Cures Act" (P.L.114-255) established in the US in 2016 stipulates in "Sec. 3060. Clarifying medical software regulation" that the Food and Drug Administration (FDA) shall not regulate the software function, including a portion of AI, for supporting the clinical judgment of a health care professional. In December 2017, the FDA announced a draft guideline for clarifying what should be regulated in terms of software supporting the clinical judgment of a health care professional and a guideline defining the principles when evaluating the safety, effectiveness, and performance of software positioned as medical equipment that should be regulated by the FDA. "Statement from FDA Commissioner Scott Gottlieb, M.D., on advancing new digital health policies to encourage innovation, bring efficiency and modernization to regulation," 2017.12.7. FDA Website <https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm587890.htm>. FDA permitted marketing of the first artificial intelligence-based device to detect certain diabetes-related eye problems on April 11, 2018, same as above <https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm604357.htm>.

[33] Precision medicine refers to the provision of optimal disease prevention and treatment at the personal level of each patient by giving consideration to genetic information and lifestyles.

[34] Satoru Miyano, "About artificial intelligence, the fundamental and key technology for the future of genomic analysis: Current situations of AI and its future problems," Japan Health Sciences Foundation. "Latest trends of the use of big data, ICT and AI in medicine: Exploring a path to make contributions to drug discovery, individualized medicine, and preemptive medicine," 2017.3, pp.137-145. <http://www.jhsf.or.jp/paper/report/report_201604.pdf> (in Japanese).; "AI gives advice on cancer treatment, detecting the type of leukemia," *Nihon Keizai Shimbun*. 2016.8.5, p.42. (in Japanese).

[35] In "Establishment of a clinical and genomic information and knowledge platform for promoting genomic medicine" selected in 2016 for the AMED's "Program for an Integrated Database of Clinical and Genomic Information", a genomic database is designed on the premise of the use of AI. Katsuyoshi Masuda, "Kyoto University and Fujitsu use AI for an integrated database of clinical and genomic information," 2016.10.10. Nikkei Technology Online Website <http://techon.nikkeibp.co.jp/atcl/news/16/101004473/> (in Japanese).; "2016 sponsored research and development report: Establishment of a clinical and genomic information and knowledge platform for promoting genomic medicine," 2016.5.31. Japan Agency for Medical Research and Development Website <https://www.amed.go.jp/content/files/jp/houkoku_h28/0401047/h28_002.pdf> (in Japanese).. In the project "Development of an integrated cancer treatment system using AI" selected for Japan Science and Technology Agency's Strategic Basic Research Program (CREST), an integrated cancer treatment system, including genomics, is being developed. Ryuji Hamamoto, "Development of an integrated cancer treatment system using AI," 2016.11.29. National Cancer Center Japan Website <https://www.ncc.go.jp/jp/information/pr_release/2016/1129/press_release_20161129_01.pdf> (in Japanese).. Others include a case of Cambridge Cancer Genomics in the UK <http://ccg.ai/>.

[36] DNA's base sequence information is called a genome, whereas other information attached to the genome is called an epigenome.

[37] Medicine based on the best scientific grounds (evidence), such as epidemiologic and statistical data.

volumes of data for a purpose similar to EBM, we need to pay attention to how data, which will be used as "evidence", are gathered and how accurate the diagnoses will be (or what is the levels and grades of evidence for that). When services in which only AI performs medical practices[38] without any intervention of doctors will be available in the future,[39] AI may take away the tasks of doctors.

(3) Diagnosis and treatment support

Multiple cases have been reported in terms of the use of AI for diagnosis and treatment support in fields other than diagnostic imaging and genomic medicine. It depends on how you define AI, but AED determines whether a person should receive an electric shock. Therefore, diagnosis and treatment support equipment using AI is already prevalent in a broad sense.

In addition to imaging, the use of AI is highly anticipated with text data, such as electronic chart, movie, and audio data containing expressions and motions, as well as diagnosis and treatment support[40] or health management using daily life data from wearable devices. In addition, various efforts have been made both in Japan and overseas.[41]

For example, Keio University is working on the development of a device to provide objective evaluations of psychiatric symptoms in real time by quantifying facial expressions, voices, and daily life activities using machine learning.[42] This device is still under development. It is a device for supporting the evaluation of severity, and therefore, it does not replace the tasks of doctors but rather reduces the work burden of doctors and psychologists. As in the other cases of the use of AI, the main issues here are the

---

[38] According to Article 17 of the Medical Practitioners Act, only doctors can engage in medical practice (practicing medicine with the will to do so continuously and repeatedly).

[39] From 2017, the Ministry of Health, Labour and Welfare is expected to sort out the relationship between Article 17 of the Medical Practitioners Act and diagnosis and treatment support, where it is unclear whether it is medical consultation or medical practice by AI. Panel for AI Utilization in Healthcare, *op.cit.* (24), p.32.

[40] The use of AI is also anticipated for improving the clinical effectiveness of treatment and optimization of costs, such as early discharge support.

[41] Cases other than the ones introduced in the body text include the following: Zahi N. Karam et al., "Ecologically valid long-term mood monitoring of individuals with bipolar disorder using speech," *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, 2014, pp.4858-4862; Colin G. Walsh et al., "Predicting Risk of Suicide Attempts over Time through Machine Learning," *Clinical Psychological Science*, Vol.5, No.3, 2017.5, pp.457-469; Skyler Place et al., "Behavioral Indicators on a Mobile Sensing Platform Predict Clinically Validated Psychiatric Symptoms of Mood and Anxiety Disorders," *Journal of Medical Internet Research*, Vol.19 No.3, 2017.3. <http://www.jmir.org/2017/3/e75/>. Others include the joint program by a British company specializing in AI DeepMind and the National Health Service (NHS) ("Working with the NHS)" DeepMind Website <https://deepmind.com/applied/deepmind-health/working-nhs/>; personalized medicine for cancer and pain management support by FRONTEO Healthcare in Japan (AI technology for the ear where more advanced and better quality medicine is anticipated") FRONTEO Healthcare website <https://www.fronteo-healthcare.com/diagnoses/> (in Japanese).; the support software "MENTAT" by Otsuka Digital Health (co-funded by Otsuka Pharmaceutical and Japan IBM) for building databases of various symptoms of mental disorders that are difficult to quantify using electric chart data and for facilitating appropriate diagnosis using IBM's AI "Watson" ("About MENTAT" Otsuka Digital Health website <https://www.mentat.jp/jp/service> (in Japanese).; and AI developed by Hitachi for predicting the risk of rehospitalization of patients with heart diseases and presenting its grounds ("Hitachi and Partners HealthCare succeeds in high-accuracy prediction of rehospitalization risks of patients with heart diseases using AI," 2017.12.12. Hitachi, Ltd. website <http://www.hitachi.co.jp/New/cnews/month/2017/12/1212.html> (in Japanese). Some improve the satisfactory level of patients during hospitalization, instead of directly supporting diagnosis and treatment. For example, IBM uses a smart speaker using AI "Watson" to perform simple operations of equipment and to answer questions within hospital rooms. "Thomas Jefferson University Hospitals Plans Cognitive Hospital Rooms powered by IBM Watson Internet of Things," 2016.10.4. IBM Website <https://www-03.ibm.com/press/us/en/pressrelease/50692.wss>. Others include iCarbonX <https://www.icarbonx.com/>, Comarch <https://www.comarch.com/healthcare/>, and Cogito <http://www.cogitocorp.com/>.

[42] 「PROMPT（Project for Objective Measures Using Computational Psychiatry Technology）」Keio University Integrated Innovation Lab for Psychiatry website <http://www.prompt-keio.jp/>; Taishiro Kishimoto, "Overview of the project "PROMPT": Characteristics of medical equipment (analysis sensor) and analysis methods, and realities of the use of AI," Japan Human Sciences Foundation, *op.cit.* (34), pp.41-47. The author (Fujita) is a member of the project.

protection of personal information, accuracy of evaluations (including trust regarding the results of AI's judgments), clarification of responsibility in the event of an error, acceptance by the community of healthcare professionals, approval as medical equipment, role of AI in the assessment of medical fees, and the treatment of intellectual property rights regarding data. There are other issues to be considered in the future. Examples include the influence on the relationship between doctors and patients, education for healthcare professionals who use the equipment, ways to handle people who do not want to use the equipment (who do not want to be analyzed), measures against economic and social discrimination associated with the results, and ways to handle the situation when general people other than doctors and psychiatrists become able to use the equipment.[43] These are issues commonly seen in other cases as well.

There are still other cases of the use of AI and robotics; for instance, chat bots (conversation programs) and robots (including those that do not necessarily have conversation capabilities via language) based on text information, such as academic papers and medical charts, are used to have conversations with patients, such as patient interviews and health advice sessions. For example, the Jichi Medical University is working on the research and development of AI for supporting doctors' diagnosis called "White Jack," which is capable of indicating the name of the diagnosis of highly suspected diseases based on information from patient interviews and displaying information on recommended tests and prescriptions on an electronic chart.[44] Further, various uses of robotics especially for dementia are note being discussed.[45]

Gathering of data for the learning and accuracy of diagnosis support creates problems when it mainly uses text information. In addition, technically, the standardization and structure of data for learning are considerable problems.[46] In terms of robotics, there are issues other than cost, such as psychological obstacles to the use of robotics and realistic effects of robotics,[47] but robotics is much anticipated as a means to contribute to reducing medical task burdens, including nursing care and elderly care.

(4) Surgery support

Because surgeons and emergency doctors are frequently required to make quick decisions during surgeries, they bear a considerable burden both mentally and physically. Even if the number of doctors as a whole increased from 2004 to 2014, the number of surgeons decreased, and the number of young surgeons

---

[43] Based on the findings of the investigations and studies by the author (Fujita).

[44] Shizukiyo Ishikawa, "Development of a comprehensive medical assistance system centered around AI," *Jichi Medical University Regional Medicine Open Lab News Letter*, Vol.107, 2016.7. <http://www.jichi.ac.jp/openlab/newsletter/letter107.pdf> (in Japanese).. Other cases include the British company Babylon, which provides a chat bot for diagnosis and triage (determination of the priority of treatment) <https://www.babylonhealth.com/>, the American company Catalia Health, which provides an interactive-type health management robot "Mabu" <http://www.cataliahealth.com/>, the Japanese companies Ubie and NAM, which provide a patient interview system using AI <http://www.company.dr-ubie.com/> (in Japanese) and <http://nam-inc.jp/>, and the Japanese company exMedio, which studies the use of AI for clinical advice for doctors ("Diagnosing skin diseases with AI is becoming reality soon, image gathering is key," *Nikkei Sangyo Shimbun*, 2017.6.30, p.9). (in Japanese).

[45] ninninPROJECT website <http://ninnin-project.com/> (in Japanese); "What is Palro?" Daiwa House Website <http://www.daiwahouse.co.jp/robot/paro/products/about.html> (in Japanese); Palro Website <https://palro.jp/> (in Japanese). For trends in service robots in the field of elderly care and medicine, see Ministry of Internal Affairs and Communications (ed.), *White Paper: Information and Communications 2016*, pp.156-162. <http://www.soumu.go.jp/johotsusintokei/whitepaper/ja/h28/pdf/28honpen.pdf> (in Japanese).

[46] Kazuhiko Oe, "Possibilities of utilizing medical information and data obtained from wearable devices for preemptive (preventive) medicine and drug discovery and future challenges," Japan Human Sciences Foundation, *op.cit.* (34), pp.21-28.

[47] Ministry of Internal Affairs and Communications. *op.cit.* (45), pp.161-162. Conversely, Hiroshi Ishiguro, professor of Osaka University and others note that autistic children sometimes open their heart to robots and androids rather than to humans. Aya Nakae et al., "Potentials of medical support by android," *Journal of orthopedics and traumatology*, Vol.58 No.8, 2015.7, pp.1057-1061.

below the age of 40 is continuously decreasing as well.[48] It is an urgent issue to reduce the burden of surgeons, and expectations are placed on AI and robotics to solve the issue.

Similar to AED as equipment for supporting diagnosis and treatment, surgery support robots using AI in a board sense, such as "da Vinci"[49] for supporting endoscopic surgeries, have already been put to practical use. Projects have been launched to optimize surgeries using the Internet of Things (IoT) and robot technology, such as "OR.NET"[50] in Germany and "Medical Device "Plug-and-Play" (MD PnP)[51] in the US. In Japan, similar programs have been launched utilizing "OPeLiNK," such as "Smart Cyber Operating Theater (SCOT)" of Tokyo Women's Medical University. [52] These projects are seeking to establish a navigation system by connecting medical devices with each other that is capable of optimizing surgeries using sensing technology and computing technology, storing surgery information in servers and analyzing it as big data, and making optimal decisions in real time. As with the mechanization of labor in other fields, it is hoped that efficiency, safety, and accuracy will increase, but there are limitations regarding the mechanical performance and cost-related issues. Liability for damages associated with malfunctions of robot surgery systems is also discussed.[53]

Takanori Fujita, National Center for Global Health and Medicine

II Elderly Care

1. Elderly care and caretakers

Japan has now become an aging society, and the number of users of care prevention services and nursing care services increased from about 5.66 million people in 2013 to about 6.14 million people in 2016.[54] There is an urgent need to secure care staff to address this situation, but it is estimated that there will be a demand-

[48] Ministry of Health, Labour and Welfare, "2014 Survey of Physicians, Dentists and Pharmacists," 2015.12.17, pp.36, 40. <http://www.mhlw.go.jp/toukei/saikin/hw/ishi/14/dl/gaikyo.pdf> (in Japanese).

[49] The da Vinci system was developed by the American company Intuitive Surgical and has been put to practical use following approval by the FDA in 2000. As of September 2017, 4,271 units have been implemented worldwide. In Japan, the system was granted pharmaceutical approval as medical equipment in 2009. As of the end of September 2016, 237 units have been implemented. "About da Vinci" Intuitive Surgical Website https://www.intuitivesurgical.com/products/davinci_surgical_system/>; "FAQs," same as above <https://www.intuitivesurgical.com/products/products_faq.php>; "About da Vinci: Situations surrounding pharmaceutical approval," Japan Robotic Surgery Society <http://j-robo.or.jp/da-vinci/yakuji-shonin.html> (in Japanese).; "About da Vinci: How they have been introduced," same as above <http://j-robo.or.jp/da-vinci/nounyu.html> (in Japanese).

[50] OR.NET Website <http://ornet.org/>.

[51] MD PnP Website <http://www.mdpnp.org/>.

[52] OPeLiNK is a system customized for medical purposes based on a communication system developed for integrating various robots and operating them in factories. SCOT improves the accuracy and safety of surgeries by coordinating and connecting various medical devices using OPeLiNK and integrating and grasping the progress of surgeries and patients' situation. Japan Agency for Medical Research and Development et al., "Completion of a prototype model of 'Smart Cyber Operating Theater' Accelerating empirical development of coordination and connection of various medical devices using IoT and starting deliberation of the clinical use of treatment system," 2016.6.16. <https://www.amed.go.jp/news/release_20160616.html>. (in Japanese).

[53] Fumio Shimpo, "Legal issues and alteration of national consciousness toward social implementation of AI," Nishimura (ed.). *op.cit.* (18), pp.52-56.

[54] Ministry of Health, Labour and Welfare, "2016 Survey of Long-term Care Benefit Expenditures: Summary Report," 2017.8.31, p.3. <http://www.mhlw.go.jp/toukei/saikin/hw/kaigo/kyufu/16/dl/11.pdf>. (in Japanese).

supply gap of 377,000 people in 2025.[55] The jobs-to-applicants ratio of care professions is constantly high,[56] while it is difficult to secure employment mainly due to low wages, great physical and mental burdens, and low social valuation. Some note dissatisfaction with working conditions, such as the shortage of manpower and difficulty in taking paid vacation.[57]

As for relationships of caretakers with those requiring care, 58% are family members living together (spouse: 25.2%, son or daughter: 21.8%, spouse of son or daughter: 9.7%), 12.2% are family members living separately, and 13.0% are service providers. Of the caretakers living together, 66.0% are female.[58] The number of those who left care professions (October 2011 to September 2012) was 101,100. Of them, 80.3% were female.[59]

As discussed above, securing a care workforce is an urgent task, while there is the reality that the share of caregiving by family members (mostly women) is very high. According to the "Survey of elderly people bedridden at home" carried out by the Japan National Council of Social Welfare in 1968, the estimated number of elderly bedridden people was about 200,000 back then, and as for "main caretakers," 25.1% were a "spouse (mainly wife)", 49.8% were the "wife of the son," and 14.5% were a "daughter."[60] As of 2013, 70% of caretakers were family members or relatives. As for the proportion of family member caretakers living together, 28.6% were the "wife," 19.1% were a "daughter," 17.8% were the "wife of the son," 3.3% were a "female relative," 13.9% were the "husband," 16.3% were a "son," 0.4% were the "husband of the daughter, and 0.6% were a "male relative."[61] These results show that care has been given mainly by family members, and this has not changed, but the proportion of caretakers who are the "wife of the son" has significantly dropped over 45 years, while the proportion of daughters and sons as caretakers has increased. Support for these caretakers will be discussed in the next section.

---

[55] Ministry of Health, Labour and Welfare, "Estimation of the Demand/Supply of Care Workforce (final figure) toward 2025," 2015.6.24, p.1. <http://www.mhlw.go.jp/file/04-Houdouhappyou-12004000-Shakaiengokyoku-Shakai-Fukushikibanka/270624houdou.pdf_2.pdf>. (in Japanese).

[56] In 2015, the ratio of all professions was 1.08, whereas the ratio in the domain of elderly care was 2.59. Welfare Manpower Promotion Office, Welfare Promotion Division, Social Welfare and War Victims' Relief Bureau, Ministry of Health, Labour and Welfare, "About efforts for securing welfare and care workforces," 2017.6.7, p.3. (regional strategy session for securing care workers (5th) (June 7, 2017) Material 1) <http://www.mhlw.go.jp/file/05-Shingikai-12201000-Shakaiengokyokushougaihokenfukushibu-Kikakuka/0000167734.pdf>. (in Japanese).

[57] Industrial Structure Policy Division, Economic and Industrial Policy Bureau, Ministry of Economy, Trade and Industry, "Report by the Study Group on the Provision of Long Term Care Services in Response to Future Long Term Care Demand," 2016.3.24, pp.31-32. <http://www.meti.go.jp/press/2015/03/20160324004/20160324004-1.pdf>. (in Japanese).

[58] Ministry of Health, Labour and Welfare, "Summary of 2016 National Livelihood Survey," 2017.6.27, p.30. <http://www.mhlw.go.jp/toukei/saikin/hw/k-tyosa/k-tyosa16/dl/16.pdf>. (in Japanese).

[59] Bureau of Statistics, Ministry of Internal Affairs and Communication, "Summary of the Results of 2012 Employment Status Survey," 2013.7.12, pp.72-73. <http://www.stat.go.jp/data/shugyou/2012/pdf/kgaiyou.pdf>. (in Japanese). Because those aged 60 or older account for about 50% of caretakers, the issue of the elderly taking care of the elderly must also be discussed (same, p.70).

[60] Chiiko Ishiguro, "About the implementation of the survey of 'bedridden elderly people'," *Japanese journal for public health nurse*, Vol.24 No.8, 1968.8, pp.26-29. (in Japanese).

[61] Akiko Saito, "Family and elderly care," Natsuki Nagata & Hiroto Matsuki (eds.), *An introduction to Sociology of Family*, Shinsensha, 2017, pp.65-81. These figures were calculated based on the elderly care sheet of the National Livelihood Survey. (in Japanese).

2. Development of robotic devices for elderly care and institutions for facilitating their introduction

The "Growth Strategy 2017"[62] and "Japan's Robot Strategy"[63] set a goal of making the size of the domestic market for robotic devices for elderly care worth 50 billion yen by 2020. The Ministry of Economy, Trade and Industry and the Ministry of Health, Labour and Welfare are playing a central role in supporting caretakers through the development of robotic devices for elderly care.[64] Their efforts include reducing care professionals' physical burden, decreasing the turnover rate of care professions and enriching care services through streamlining tasks, and creating a regional comprehensive care system (discussed later) through continuous support for the independent livelihood of the elderly in the community.

(1) Support for care and welfare facilities and care service providers (experiment and introduction projects)

Below are representative subsidized projects for supporting care and welfare facilities and care service providers.

The "Special project for supporting introduction of elderly-care robots, etc." was a one-time-only project realized by the 2015 supplementary budget, and it subsidized a maximum of 927,000 yen per facility and provider as expenses for introducing elderly care robots priced over 200,000 yen. The project is finished at this point.

The "Project for supporting introduction of nursing-care robots and empirically studying its effectiveness" (2017) was a one-time-only project realized by the second supplementary budget of 2016 to subsidize the cost for introducing elderly care robots (maximum 2,000,000 yen) and cost for investigating (fixed amount of 300,000 yen) facilities that would cooperate in an empirical study of elderly care robots.

Many of the "projects for supporting introduction of elderly-care robots" implemented by prefectures using the "Fund for Comprehensively Securing Regional Health and Long-term Care in Japan (Fund for long-term care)"[65] subsidize half the cost of introducing elderly care robots (maximum 100,000 yen per robot).[66] Some municipalities set their own subsidy rate, such as Komatsu City in Ishikawa Prefecture (up to 500,000 yen per service provider, subsidizing no higher than 1/2 for units purchased and no higher than 2/3 for units leased).[67]

The Ministry of Health, Labour and Welfare considers that elderly watching robots (watching sensors) can replace a portion of the staff working in special nursing homes and announced that conditions for adding

---

62 "Growth Strategy 2017" *op.cit.* (7).< https://www.kantei.go.jp/jp/singi/keizaisaisei/pdf/miraitousi2017_inttv_prgrm.pdf >

63 "Japan's Robot Strategy" (decided by the Headquarters for Japan's Economic Revitalization on February 10, 2015), Office of Prime Minister Website <https://www.kantei.go.jp/jp/singi/keizaisaisei/pdf/miraitousi2017_inttv_prgrm.pdf>.

64 Division of Support for the Elderly, Health and Welfare Bureau for the Elderly, Ministry of Health, Labour and Welfare & Industrial Machinery Division, Manufacturing Industries Bureau, Ministry of Economy, Trade and Industry, "Priority areas to which robot technology is to be introduced in nursing care of elderly" (formulated in November 2012 and revised in October 2017) <http://www.mhlw.go.jp/file/04-Houdouhappyou-12304250-Roukenkyoku-Koureishashienka/0000180157.pdf>. (in Japanese).

65 This is a fund established at prefectures using the increase in revenue from consumption tax to improve care facilities and secure care professionals.

66 Division of Support for the Elderly & Division of Promotion, Health and Welfare Bureau for the Elderly, Ministry of Health, Labour and Welfare, "About the projects using the "Fund for Comprehensively Securing Regional Health and Long-term Care in Japan" (Fund for long-term care)" (notification to the long-term care insurance department of each prefecture), 2015.1.16; "Subsidies for 2017 projects for supporting introduction of elderly-care robots [list by prefecture]," updated on October 17, 2017. Kaigo Robot ONLINE Website <https://kaigorobot-online.com/contents/33>. (in Japanese).

67 "Subsidies for projects to promote introduction of elderly-care robots," Komatsu City Website <https://kaigorobot-online.com/contents/33>. (in Japanese).

nursing care fees, which are added according to the number of personnel allocated during nighttime, will be relaxed for care service providers introducing sensors in the 2018 revision of nursing care fees.[68]

(2) Support for those in need of long-term care (long-care insurance program)

Some elderly care robotic devices are covered by the insurance payment for the lending of welfare equipment appropriate for the level of care needed, as defined by the long-term care insurance program.[69] The number of welfare devices leased using the long-term care insurance system is constantly increasing, although there are some variations in the degree of the increase depending on the type of device.[70] As for elderly care robotic devices not covered by insurance payments from the long-term care insurance system at the moment, possibilities for including them as devices covered for lease or purchase may be discussed at the "Committee for evaluating welfare devices and home renovation covered by the long-term care insurance system" of the Ministry of Health, Labour and Welfare.[71] As of 2014, the committee decided to look into the possibilities of including "communication robots," "elderly watching robots," "robotic suits," and elderly care robots for "toilet support" and "mobility support" within the coverage of the long-term care insurance system.[72] In addition to the above, the committee is also looking into the possibility of including "drug-administration robots" and "sensor devices for detecting wandering dementia patients" during the meetings held in 2015 and onward.[73] Some municipalities have carried out projects for leasing elderly care robotic devices not covered by the long-term care insurance system, for which users will bear 10% of the cost.[74]

3. Long-term care support using elderly care robotic devices

Hereinafter, we will discuss "communication robots" and "elderly watching," as particularly relevant to AI among the elderly care robotic devices designed for supporting people in need of long-term care.

(1) Communication robots

In 2016, the AMED's "Project to Promote the Development and Introduction of Robotic Devices for Nursing Care" implemented a large-scale empirical experiment on the use of communication robots in the field of long-term care. The report containing the results of this experiment showed that about one-third of

---

68 "About revisions in each service in the 2018 revision of nursing care fees" (Committee for Long-Term Care Benefit Expense of the Social Security Council (158th meeting) (January 26, 2018) (Reference material 1), pp.116, 211. <http://www.mhlw.go.jp/file/05-Shingikai-12601000-Seisakutoukatsukan-Sanjikanshitsu_Shakaihoshoutantou/0000192302.pdf>. (in Japanese).

69 For example, a walking support device equipped with robot technology developed by RT.WORKS called "Robot Assist Walker RT.2," "Robot Assist Walker RT.2" RT.WORK Website <https://www.rtworks.co.jp/eng/product/rt2.html>.

70 Ministry of Health, Labour and Welfare, "Summary of the Survey of Long-term Care Benefit Expenditures," 2017.8.31, p.11. <http://www.mhlw.go.jp/toukei/saikin/hw/kaigo/kyufu/16/dl/11.pdf>. (in Japanese).

71 Ministry of Health, Labour and Welfare, "Guidelines for developing welfare devices and elderly-care robots." 2014.3, p.10. Association for Technical Aids Website <http://www.techno-aids.or.jp/research/robotebiki_mhlw_140922.pdf>. (in Japanese).

72 "About welfare devices to be used in the priority areas to which robot technology is to be introduced in nursing care of elderly," 2014.10.28. (Committee for evaluating welfare devices and home renovation covered by the long-term care insurance system (1st meeting in 2014) (October 28, 2014) Material 5-3), Ministry of Health, Labour and Welfare Website <http://www.mhlw.go.jp/file/05-Shingikai-12301000-Roukenkyoku-Soumuka/0000094783.pdf>. (in Japanese).

73 "About the types of welfare devices to be considered," 2015.11.9. (Committee for evaluating welfare devices and home renovation covered by the long-term care insurance system (1st meeting in 2015) (November 9, 2015). Same as above <http://www.mhlw.go.jp/file/05-Shingikai-12301000-Roukenkyoku-Soumuka/1109-5-1.pdf>. (in Japanese).

74 "About the model project for elderly-care devices leasing," Okayama City website <http://www.city.okayama.jp/hofuku/hokenfukushiseisaku/hokenfukushiseisaku_00084.html>. (in Japanese).

the 866 subjects of the experiment experienced improvement in the areas of "self-care" and "motor & mobility," which are closely linked to long-term care in particular.[75] This report divides communication robots into three categories, "situation detection and adaption robots," "environment & operation reactive robots," and "program implementation robots replacing caretakers."[76] "Situation detection and adaption robots" refer to robots that detect the status (hours in the recumbent position, hours in the sitting position, hours spent in the room) of the person to be cared for and that take actions with purposes. For example, "A-Isense" by IntelliVoice responds to instructions from the elderly watching robot and takes actions such as encouraging a person who has spent more than a certain number of hours in the sitting position to do some exercise.[77]

"Environment & operation reactive robots" refer to robots that react to operations given to the robot (including touching and talking) and the surrounding environment. "Program implementation robots replacing caretakers" refer to robots that replace caretakers in terms of encouragement (mainly recreation, etc.). Many of the functions categorized or "environment & operation reactive robots" and "program implementation robots replacing caretakers" have already been put to practical use. For example, a communication robot developed by Vstone, robots equipped with communication functions using an AI technology brand of NTT Group "corevo,"[78] and "PALRO"[79] developed by Fujisoft are known among them.

In terms of PARLO, units for professional use and for research purposes are already available in the market, and units for home use are already in the process of commercialization. In addition to the current communication functions and remote-call functions, a function that sends information, such as the user's conversations, to family members living separately will be given to units for home use.[80] Equipping communication robots with the elderly watching technology is very novel because the robots will be able to perform "communication" and "watching over" functions simultaneously.

(2) Elderly watching support

The conventional elderly watching support technology was designed to detect motions when patients get up from the bed, turn over, fall, and wander based on changes in the signals, such as weight, motion, body temperature, and sound volume, using sensing technology. In recent years, development has been under way to have AI acknowledge the information and accumulate it as data in the network so that the system can plan preventive measures, not only by watching the motions mentioned above, but also by detecting

[75] Yayoi Okawa, "Report of the large-scale empirical experiment on the use of communication robots in the field of long-term care: Project to Promote the Development and Introduction of Robotic Devices for Nursing Care (project for standard setting and evaluation) 'Survey of the development of robotic devices for nursing elderly care'," 2017.5.31 (revised on 2017.7.27), pp.12-13. "Robotic Devices for Nursing Care Project" Website <http://robotcare.jp/wp-content/uploads/2017/07/communi_robo_veri_test_report.pdf>. (in Japanese).

[76] Same as above, pp.4-7.

[77] "2016 Project to Promote the Development and Introduction of Robotic Devices for Nursing Care (project for standard setting and evaluation) "Survey of the development of robotic devices for elderly care," Robot list: A-Isense" Japan Agency for Medical Research and Development Website <https://www.amed.go.jp/content/000003893.pdf>. (in Japanese).

[78] "Revitalizing the robot market with cloud service capable of handling various robots and purposes: Cloud-based robot platform service 'RoboConnect' launched on September 1," 2016.8.30. NTT Group Website <http://www.ntt.co.jp/corevo/topics11.html>. (in Japanese).

[79] "PARLO" Fujisoft Website < https://palro.jp/en>.

[80] "PARLO launches the first home use version capable of sending information of users to family, Fujisoft," 2017.10.12. Nursing care news site "Joint" Website <http://www.joint-kaigo.com/article-5/pg31.html>.(in Japanese).

predictive behaviors and understanding action patterns. Recent ones include OWLSIGHT[81] by Care Dynamics.

4. Task support using AI

(1) Automatic creation of care plans

A care plan refers to a plan for using long-term care services that a care manager (long-term care support specialist) creates based on the health condition of the person receiving care, activities of daily living, the person's wishes, and the living situations of family members, including short-term and long-term goals. There is a great burden associated with the creation of care plans,[82] and AI technology is expected to reduce that burden.

IT tools for automatically creating care plans are covered by the Ministry of Economy, Trade and Industry's "Project to support IT introduction to enhance services and productivity (IT Introduction Subsidies),[83] and they are expected to reduce the burdens associated with long-term care.

(2) Studies regarding the automatic creation of care plans

The Saint-Care Holding Corporation, which provides care services, carried out joint research for applying AI in the creation of care plans together with Stanford Artificial Intelligence Laboratory and Stanford Clinical Excellence Research Center and published a report in March 2017. During this research, they used data on users of a long-term care insurance system living in Wako City, Saitama Prefecture (2010 to 2015) (8,595 people) to have AI learn items for the certification of long-term care needs, reports from the doctors in charge, and the weekly schedule for service usage as datasets, to read the actual cases, and to output the frequency of the use of services. The results of evaluating the care plans based on the output revealed some issues, such as the need to have it learn more data, including information from users of the long-term care insurance system (current medical history, economic status, living situation, etc.), plans for long-term care prevention services and support, prognostic prediction, and service contents, as well as the need to clarify the definitions of independence or independent support.[84] In April 2017, Saint-Care established a new company called "Care Design Institute Inc." to achieve AI utilization in elderly care settings. The company also launched an empirical project for care plan preparation using AI together with Toyohashi City, Aichi Prefecture, in July of the same year.[85]

---

[81] "OWLSIGHT," Care Dynamics Website <http://www.care-dynamics.jp/owlsight/>. (in Japanese).

[82] For example, according to the survey conducted by the Nagasaki Care Manager Liaison Committee, it took 75 minutes to create a plan for continued users and 120 minutes to create a plan for new users as of 2012. "Proposal to the national government: Time required for care management, Nagasaki Care Manager Liaison Committee," 2012.1.4. Silver Industry News Website <http://www.care-news.jp/news/caremana/care_nagasaki_11_12_10.html>. (in Japanese).

[83] This is a project for subsidizing a portion of the expenses, such as operating costs, for the introduction of IT tools (software, service, etc.) to increase the productivity of small and medium-sized businesses and small-sized service providers. "IT Introduction Subsidies (2016 supplementary budget, project to support IT introduction to enhance service and productivity)," Service Design Engineering Council
Website <https://www.it-hojo.jp> (in Japanese). This is a project realized by the 2016 supplementary budget, but a similar project will be implemented using the 2017 supplementary budget.

[84] Saint-Care Holding Corporation, "Report on the research of possibilities of AI introduction in care plan preparation and its challenges for promoting independence support," 2017.3, pp.3-4.
<http://v4.eir-parts.net/v4Contents/View.aspx?template=ir_material&sid=71259&code=2374>. (in Japanese).

[85] Yoshikatsu Masuda, "Empirical project for care plan preparation by AI launched," 2017.7.12. Nikkei Digital Health Website <http://techon.nikkeibp.co.jp/atcl/news/16/071108329/?ST=health>. (in Japanese).

5. Problems surrounding elderly care

The introduction of robotic devices for elderly care may mitigate the physical and mental burdens of caretakers and people in need of care. On the other hand, there are problems that cannot be solved easily at the moment. Below, we will describe two of these problems.

(1) Watching over or monitoring?

Monitoring people in need of care using sensing technology has benefits, such as predicting and preventing dangerous behaviors, whereas some note the problem of interference with the free will of people in need of care.[86] Robots for supporting both communication and elderly watching, such as PARLO for home use, come with the issue of protecting the right to privacy of people in need of care.

There is a report that when developing and introducing a camera system for supporting elderly watching for use in long-term care facilities, the facility selected for the project expressed reservations about the development and introduction of the system at first, because one of the prefecture's nursing care facility evaluation items stated that "the elderly should not be monitored with cameras in an effort to facilitate elderly watching."[87] As indicated by this case, it is difficult to determine where to draw a line between elderly watching using a watching support system and monitoring. Similar problems are expected to occur when developing and introducing elderly watching support technology in the future.

(2) 2017 amendment to the Long-Term Care Insurance Act centered on the integrated community care system

The amendment to the Long-Term Care Insurance Act in 2017[88] reinforced a system for providing home, healthcare, nursing care, prevention, and livelihood support comprehensively, called the "the integrated community care system." What is noteworthy here is the introduction of coexistence-type services. Traditionally, when people with disabilities reach the age categorized as "elderly," they have no choice but to stop using welfare service for persons with disabilities, which they had been using, and to start using service providers covered by long-term care insurance, owing to the principle that prioritizes long-term care insurance. This amendment eliminated the distinction between the elderly and the disabled; thus, people with disabilities who have turned 65 are not allowed to continue living in a facility they are used to. Along with the introduction of coexistence-type services, appropriate utilization of the limited human resources engaging in welfare according to the reality of communities was addressed. However, because the special knowledge and skills required in welfare for the disabled and long-term care for the elderly are different, there is another issue of securing care professionals who are specialized in both.

As the issue of the expertise of care professions in the coexistence-type services has been noted, it is necessary to discuss how robotic devices for elderly care and AI can substitute or support the tasks of care professionals.

---

[86] Noel Sharkey and Amanda Sharkey, "The eldercare factory," *Gerontology*, Vol.58 No.3, 2012.4, pp.282-288.

[87] Taro Sugihara et al., "Problems associated with the development and introduction of a camera system for supporting demented elderly watching at group homes," *Journal of Sociotechnology Research Network*, Vol.7, 2010.3, pp.54-65. <https://www.jstage.jst.go.jp/article/sociotechnica/7/0/7_0_54/_pdf/-char/ja>. (in Japanese).

[88] Act for the Partial Revision of the Long-Term Care Insurance Act, etc. for the Reinforcement of the Integrated Community Care System (Act No. 52 of 2017). It came into effect on April 1, 2018 (Supplementary Provision Article 1).

Naonori Akiya, Yamaguchi University

III Art and Design

1. Work of people involved in art and AI technology

Some note that it is difficult for AI to replace jobs that require creativity in the field of art and design.[89] On the other hand, AI that can automatically perform part of production activities is now being developed and used, such as composition, musical performance, coloring of line drawings, and website design. The products created by AI may be accepted as works of art and distributed in the market,[90] or some expect that AI may bring out new aesthetic value that differs from that of works of art created by people.[91] In this chapter, we will overview the ongoing research projects and service trends in this area and then discuss AI with a focus on AI's influence on creators involved in the process of developing ideas and producing works.

Creators' work styles are diverse, from freelancers (self-employed), those who have an employment contract, to those engage in subcontract work. Many of them are faced with low incomes, long working hours, and a lack of social security, struggling to balance work with life.[92] On the other hand, for clients who use the works of creators for advertising purposes, the primary objective is to transmit information they want to convey effectively. For example, in the field of composition, it is said that anyone will be able to generate many pieces of music suited for this objective using AI technology.[93] If clients can get pieces of music they need in a short amount of time at lower costs through composition services using AI, this could be an attractive application. Similar advantages may apply in fields other than composition, as discussed later.

2. Artwork creation services using AI and the status of research and development

(1) Services to create music, images, and the like

Since the mid-2010s, there have been services in Japan and overseas that provide data generated through systems using machine learning and deep learning, which do not require specialized knowledge on the part of users. Examples include music creation (composition),[94] coloring of line drawings and image

---

[89] Carl Benedikt Frey and Michael Osborne, *The Future of Employment. How susceptible are jobs to computerisation?*, Oxford Martin Programme on Technology and Employment, 2013, p.26. <https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf>.

[90] Sarah Cascone, "Google's 'Inceptionism' Art Sells Big at San Francisco Auction," 2016.3.2. artnet news <https://news.artnet.com/market/google-inceptionism-art-sells-big-439352>.

[91] Hideki Nakazawa, "Manifesto of Artificial Intelligence Art and Aesthetics," 2016.4.25. Artificial Intelligence Art and Aesthetics Research Group website https://www.aloalo.co.jp/ai/manifesto_e.html >

[92] Yayoi Yosizawa, "Labor in art projects," 2015.6.9. Explat Website <http://www.explat.org/news/2015/Yoshizawa.html> (in Japanese).

[93] Jordan Passman, "Music As A Commodity: Songwriting With Artificial Intelligence," Mar 3, 2017. Forbes Website <https://www.forbes.com/sites/jordanpassman/2017/03/03/music-as-a-commodity-songwriting-with-artificial-intelligence/>.

[94] "Amper Music" in the US and "Jukedeck" in the UK are representative music creation services. Music will be automatically created once the genre, mood, and time of performance are selected. Amper Music Website <https://www.ampermusic.com/>; Jukedeck Website <https://www.jukedeck.com/>.

processing,[95] and website design.[96] By using these services, users can freely create and transmit music data or image data with a certain level of quality with easy-to-use manipulations without worrying about fees from using copyrights.

(2) Research and development projects

Research and development for creating works according to the taste and sense of individuals is also under way. In the domain of music, the research group led by Professor Noriko Otani of Tokyo City University is developing a system for composing music consistent with the taste of individuals based on their choices of music,[97] while the Center of Innovation (COI) Site ("Developing 'Super Nippon-Jin' by Activating Human Power") led by Osaka University is developing a system for measuring the brain waves of individuals and composing music suited to their mood.[98] "Flow Machines"[99] is a project that Sony Computer Science Laboratories is working on for extracting a composer's style from data, such as existing musical scores and lyrics, and creating new music based on them.

In the field of fine arts, there is a project called "The Next Rembrandt,"[100] which the Delft University of Technology and Mauritshuis jointly works on as a project for generating images that imitate the styles of existing artists. In 2016, the project announced a work of art created by extracting the painting style of Rembrandt van Rijn[101] from the scanned data of his works, generating a new Rembrandt-style portrait, and outputting it as an oil painting-like image using a 3D printer.

(3) Value of the creations of AI

A piece created using "Deep Dream," an image recognition and generation system developed by Google, was purchased for 8,000 dollars through an auction in the United States.[102] This indicates that AI-created works of art have market value. At the moment, however, some say that these services and research and development projects are not at a level that can replace human composers or artists.[103] Right now, it is noted that what are considered AI creations are not necessarily what AI created autonomously; rather, they

---

95 PaintsChainer is one of the coloring services of line drawings for illustrators. As cases of image processing, there are apps such as Prisma and Pikazo for converting photos into images that imitate the styles of impressionists or cubism. PaintsChainer Website <https://paintschainer.preferred.tech/index_ja.html>(in Japanese); "Prisma." Google Play Website <https://play.google.com/store/apps/details?id=com.neuralprisma&hl=ja>; "Pikazo – AI Art." iTunes Website <https://itunes.apple.com/us/app/pikazo-ai-art/id1100723148?mt=8>.

96 For example, there is an AI-based website production service in Japan called HONMONO, as well as The Grid and Wix overseas.
HONMONO Website <http://honmono.click/> (in Japanese); The Grid Website <https://thegrid.io/>; "The Future of Website Building Is Here," WiX.com Website <https://www.wix.com/about/adi-get-access>.

97 "Professor Otani studies automated creation of music using artificial intelligence," 2016.11.8. Mainichi Shimbun Website <https://mainichi.jp/univ/articles/20161108/org/00m/100/015000c>(in Japanese).

98 Osaka University, "Developing artificial intelligence for automatically composing music based on the brain waves," 2017.1.16. Osaka University Resou Website <http://resou.osaka-u.ac.jp/ja/research/2017/20170116_1> (in Japanese).

99 Flow Machines Website <http://www.flow-machines.com>. Bach-style music called "DeepBach" and the Beatles-style music "Daddy's Car" created in this project have been released on YouTube.

100 The Next Rembrandt Website <https://www.nextrembrandt.com/>.

101 A Dutch painter who represents the baroque period. Famous for pieces such as *The Night Watch* (1642).

102 Alex Rayner, "Can Google's Deep Dream become an art machine?" *Guardian*, 2016.3.28. <https://www.theguardian.com/artanddesign/2016/mar/28/google-deep-dream-art>.

103 For example, there was a reaction such as the following: "At the moment, I cannot find anything that has realized the quality of music available in the market through fully automated composition." (Hiromichi Yamada "AI composition grows rapidly, future of music turning into commodity," 2017.5.2. EYS Music School Website <http://www.eys-musicschool.com/media/ai_musiccomposition/> (in Japanese)).

are what has been created using AI as a tool with certain contributions from people.[104] For example, the Beatles-style music released as a creation of "Flow Machines" was arranged by a human composer.[105]

Thus, it is probably still too early to conclude that the creations of AI have the same artistic value as works created by people. Yet, if AI technology advances further in the future and if the quality of the works created automatically exceeds that of creators, then we will no longer need to have humans produce such works. In the long run, to secure creators' activities, we need to find some sort of added value that cannot be created by AI, such as unique personalities and styles.

3. The issue of copyrights

The issue of copyrights is considered to be among influences of works created by AI have on creators. In Japan, this issue has been vigorously debated among, for example, the "New Information Goods Committee" of the Intellectual Property Strategy Headquarters.[106]

The Copyright Act in Japan (Act No. 48 of 1970) stipulates that a "work means a production in which thoughts or sentiments are expressed in a creative way and which falls within the literary, scientific, artistic or musical domain." AI does not have such thoughts or sentiments, and the creations of AI are thus not considered to have copyrights.[107] Then, do all of AI creations not have copyrights? The "Reports of works produced with the aid of a computer" published in 1993 by the Copyright Council stipulated a policy that works autonomously created by systems do not have copyrights, but when systems are used by humans as a tool, a copyright is granted to the person who operates the systems.[108]

If we look at cases overseas, the copyright of a British music creation service using AI called "Jukedeck" belongs to "Jukedeck," but users can use what AI has created for free. However, they can also purchase the copyright from "Jukedeck."[109] The works painted with an AI-based painting program called "AARON" created by Harold Cohen are exhibited at the Victoria and Albert Museum in the UK. On the website of the museum, Cohen is listed as the artist who has the copyright, and AARON is listed as the painting tool and

---

[104] Intellectual Property Strategy Headquarters, Verification, Evaluation, and Panning Committee, New Information Goods Committee, "Report of the New Information Goods Committee: Toward establishment of intellectual property system foundational to the reinforcement of industrial competitiveness through promotion of the use of data and artificial intelligence (AI)," 2017.3, pp.25-26. Office of Prime Minister Website <http://www.kantei.go.jp/jp/singi/titeki2/tyousakai/kensho_hyoka_kikaku/2017/johozai/houkokusho.pdf> (in Japanese).

[105] The commentary attached to the released movie for "Daddy's Car" says that the French composer Benoît Carré wrote lyrics for the music generated by "Flow Machines" and arranged the song. "Daddy's Car: a song composed by Artificial Intelligence - in the style of the Beatles." YouTube Website <https://www.youtube.com/watch?v=LSHZ_b05W7o>.

[106] Intellectual Property Strategy Headquarters, Verification, Evaluation, and Panning Committee, New Information Goods Committee, *op.cit.* (104) (in Japanese).

[107] Takushi Ootani, "Artificial intelligence, art, and copyright: If art isn't an expression of thoughts and emotions, then why can we call it the product of human creativity?" *Journal of information processing and management*, Vol.60 No.8, 2017.11, p.594. <https://www.jstage.jst.go.jp/article/johokanri/60/8/60_594/_pdf/-char/ja>(in Japanese).

[108] Agency for Cultural Affairs, "Report of the 9th subcommittee of the Copyright Council (related to computer-generated works)," 1993.11. Copyright Research and Information Center Website <http://www.cric.or.jp/db/report/h5_11_2/h5_11_2_main.html>(in Japanese). The same was confirmed in the report put together by the Intellectual Property Strategy Headquarters in 2016. Intellectual Property Strategy Headquarters, Verification, Evaluation, and Panning Committee, Next Generation Intellectual Property System Review Committee, "Report of the Next-generation Intellectual Property System Review Committee: Toward establishment of next generation intellectual property system corresponding to digital networks," 2016.4, p.22. <https://www.kantei.go.jp/jp/singi/titeki2/tyousakai/kensho_hyoka_kikaku/2016/jisedai_tizai/hokokusho.pdf>(in Japanese).

[109] Licensing term 3.3.7 of "Jukedeck" says that "Jukedeck" is and remains the owner of the copyright of the music generated, and licensing term 3.4.1 says that if a user purchases a track, then "Jukedeck" transfers ownership of the track to the user. "Licensing." Jukedeck Website <https://www.jukedeck.com/licensing>.

technique used.[110] The museum sees the person who developed and used the system as the creator of the paintings.

The Copyright, Designs and Patents Act 1988 (1988 c. 48) in the UK stipulates that, in the case of a literary, dramatic, musical, or artistic work that is computer generated, the author shall be taken to be the person by whom the arrangements necessary for the creation of the work are undertaken, in circumstances such that there is no human author of the work, acknowledging copyrights to computer-generated works (Section 9, (3) and Section 178).[111] However, the arrangements necessary for the creation of a work are not defined clearly. Therefore, we cannot deny the possibility that the verdict may differ depending on the degree of AI's involvement, and therefore, we need to be careful as to who holds the copyright.[112]

In addition, a problem arises for creators when the works to which they hold the copyright are used as data for AI learning. In Japan, the "Interim Report of the Legislative and Basic Issues Subcommittee of the Subdivision on Copyright, Council for Cultural Affairs" presented a view in February 2017 that using the works of others as data for AI learning does not necessarily harm the interests of the persons who own the copyrights, and their rights can be restricted for this purpose.[113] The report notes the necessity to build archives of data used for learning and to make it available to the public in relation to this. On the other hand, it is difficult to make data open using uniform rules, because some businesses provide certain data and charge related fees. It has been noted that it is necessary to establish a carefully crafted system, by looking into what data should be open and what data should not be open by domain.[114]

4. Human creators of the future and their involvement with AI

There are at least the following three ways in which creators may be involved with AI technology: (1) playing a part in the development of AI that can be applied in the domain of art, (2) using AI technology as a tool for producing their own works, and (3) competing with AI technology when receiving production jobs.

Photos and paintings previously used to influence the styles of each works, and portrait painters faded away. Similarly, it is expected that AI-generated works in the domain of art and creators' artworks will influence each other, which may change means of expression and job styles. Creators will probably be further required to offer "something" that cannot be achieved by AI.

Reina Saijo, Kyoto University

---

[110] "0305-03." V&A Search the Collections Website <http://collections.vam.ac.uk/item/O114802/0305-03-print-cohen-harold/>.

[111] Japanese translation of the act: Yukifusa Oyama & Tetsuya Imamura (tra.) "Collection of Foreign Copyright Laws (53): United Kingdom," Copyright Research and Information Center, 2016.3. <http://www.cric.or.jp/db/world/england/england2.pdf>. The right does not apply in relation to works created by computers (Article 79, (2) of the same act), and the copyright expires in 50 years, which is shorter than the 70 years set for ordinary works (Article 12, (7) of the same act). Works created by humans are the premise of copyright protection in the copyright laws of other countries, including those in the US. Generally, works created by AI autonomously (with no human creators) are not covered by copyright protection. Andres Guadamuz, "Artificial intelligence and copyright," *WIPO Magazine*, 2017, No.5, 2017.10, pp.14-19. <http://www.wipo.int/export/sites/www/wipo_magazine/en/pdf/2017/wipo_pub_121_2017_05.pdf>.

[112] Toby Bond, "Artificial Intelligence and IP – Part 2: IP in AI Generated Content," 2017.6.16. DigitalBusiness.Law Website <http://digitalbusiness.law/2017/06/artificial-intelligence-and-ip-part-2-ip-in-ai-generated-content/>.

[113] Legislative and Basic Issues Subcommittee of the Subdivision on Copyright, Council for Cultural Affairs, "Interim Report of the Legislative and Basic Issues Subcommittee of the Subdivision on Copyright, Council for Cultural Affairs," 2017.2, pp.46-47. .Agency for Cultural Affairs Website <http://www.bunka.go.jp/seisaku/bunkashingikai/chosakuken/pdf/h2902_chukanmatome.pdf>(in Japanese)..

[114] Intellectual Property Strategy Headquarters, Verification, Evaluation, and Panning Committee, New Information Goods Committee, *op.cit.* (104), pp.27-29 (in Japanese).

IV Education

1. Overview of the domain of education

In the current Second Basic Plan for the Promotion of Education, four basic policy directions of the educational administration are stipulated: (1) developing social competencies for survival, (2) developing human resources for a brighter future, (3) building safety nets for learning, and (4) building bonds and establishing vibrant communities. The plan also addresses problems, such as improving the situation of bullying, non-attendance at school, and high school dropouts and securing opportunities for educational advancement irrespective of students' financial situation.[115] In addition, the following issues will be addressed in the Third Basic Plan for the Promotion of Education to commence in fiscal year 2018; (1) changes in school attendance and work structures due to the declining birthrate and aging population, (2) changes in the industrial structure and society due to technological innovations and globalization, (3) fixation of disparities, such as poverty of children, (4) regional problems, such as regional gaps, and (5) changes in the situations surrounding children.[116]

To solve these problems, it is necessary to take a number of measures, such as reforms to conventional education and diversification of educational content, which would significantly increase the burden on teachers in schools. Therefore, the Ministry of Education, Culture, Sports, Science and Technology - Japan is working on a plan to establish ICT facilities in schools[117] in order to streamline tasks and address abilities to utilize information (including programming education) in the next Course of Study for Elementary School to improve the ICT literacy among Japanese people.[118] Thus, the ministry is gradually introducing ICT both in educational environments and in educational content. In this paper, therefore, we will put a spotlight on the use of AI and ICT mainly in elementary and secondary education.

2. Issues in the domain of education

(1) Dealing with various learners

The proportion of non-attendance in elementary and lower secondary schools in 2016 was 1.35%; it has been increasing since 2012 (1.09%).[119] In addition to non-attendance, when children have difficulties commuting to school due to sickness or financial reasons or when children and students come back to Japan

---

[115] "Basic Plan for the Promotion of Education" (Cabinet decision on June 14, 2013" Ministry of Education, Culture, Sports, Science and Technology Website
< http://www.mext.go.jp/en/policy/education/lawandplan/title01/detail01/sdetail01/1373808.htm>.

[116] Central Council for Education's Committee for Basic Plan for the Promotion of Education, "Basic ideas toward development of the Third Basic Plan for the Promotion of Education," 2017.1.19, pp.3-8. Ministry of Education, Culture, Sports, Science and Technology Website
<http://www.mext.go.jp/component/b_menu/shingi/toushin/__icsFiles/afieldfile/2017/02/06/1381849_01_1.pdf>. (in Japanese)

[117] Ministry of Education, Culture, Sports, Science and Technology, "Let's establish an ICT environment at school: Four-year plan for establishing an environment to address IT utilization in education," 2014. <http://jouhouka.mext.go.jp/school/pdf/2014ICT-panf.pdf>. (in Japanese)

[118] Ministry of Education, Culture, Sports, Science and Technology, "Points for the revision of Course of study for Kindergarten and Course of study for Kindergarten for Elementary and Lower Secondary School," 2016.6.16.
<http://www.mext.go.jp/a_menu/shotou/new-cs/__icsFiles/afieldfile/2017/06/16/1384662_2.pdf>. (in Japanese)

[119] Student Affairs Division, Elementary and Secondary Education Bureau, Ministry of Education, Culture, Sports, Science and Technology, "About 2016 Survey of problematic behaviors of students and various problems in student guidance, such as non-attendance (preliminary figures)," 2017.10.26, p.64.
<http://www.mext.go.jp/b_menu/houdou/29/10/__icsFiles/afieldfile/2017/10/26/1397646_002.pdf>. (in Japanese)

from overseas, it is necessary to address differences in learning level through supplementary classes, which impose a burden on teachers.

(2) Dealing with diverse learning contents

The Second Basic Plan for the Promotion of Education has as its directions developing creativity, a challenging spirit, leadership, Japanese identity, and language and communication skills and enhancing excellent abilities and various personalities.[120] However, dealing with these various tasks in education may impose a great burden on teachers.

(3) Dealing with tasks other than lessons

In schools, there are tasks other than lessons, such as providing learning guidance, processing academic results, managing grades and classes, and performing desk work. For example, in lower secondary schools, 38 minutes are spent per day on tasks related to the management of grades and classes (2016), which is an increase of 11 minutes from 2006, while 38 minutes are spent on the processing of academic results (2016), which is an increase of 13 minutes from 2006.[121] In this regard, there has been a demand for the use of ICT and related technology to reduce the burden of desk work in schools.[122]

3. Cases of the use of AI and ICT

(1) Massive Open Online Courses

In the *White Paper on Science and Technology 2016*, Massive Open Online Courses (MOOCs) are cited as a method to "innovate the learning environment using ICT (to innovate educational methods)".[123] In Japan, JMOOC (Japan Massive Open Online Courses Promotion Council)[124] has been launched, while Khan Academy[125] is in operation in the United States. As for books and conventional types of teaching materials for correspondence education and the like, students need to purchase and obtain teaching materials for the subjects and domains they want to learn, which creates a great financial and procedural burden. However, with MOOCs, many teaching materials are available 24 hours a day from a PC or a tablet, and the amount of such materials is increasing every day.[126] This allows students to deal with various learning contents at home. In addition, some teaching materials accommodate elementary to advanced levels or multiple languages so that diverse learners can use them.

---

[120] "Basic Plan for the Promotion of Education" (Cabinet decision on June 14, 2013), Ministry of Education, Culture, Sports, Science and Technology Website < http://www.mext.go.jp/en/policy/education/lawandplan/title01/detail01/sdetail01/1373808.htm >.

[121] Ministry of Education, Culture, Sports, Science and Technology, "About the results of the survey of working conditions of teachers (preliminary figures)," 2017.4.28. <http://www.mext.go.jp/b_menu/houdou/29/04/__icsFiles/afieldfile/2017/04/28/1385174_001.pdf>. (in Japanese)

[122] For example, Central Council for Education, "Regarding the Revision of Courses of Study for Kindergarten, Elementary School, Lower Secondary School, Upper Secondary School, and Schools for Special Needs Education (Report), 2008.1.17, p.140. Ministry of Education, Culture, Sports, Science and Technology Website <http://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/__icsFiles/afieldfile/2009/05/12/1216828_1.pdf>. (in Japanese)

[123] Ministry of Education, Culture, Sports, Science and Technology (ed.), *2016 White Paper on Science and Technology*, 2016, pp.173-176. < http://www.mext.go.jp/component/english/__icsFiles/afieldfile/2017/04/14/1384513_011.pdf >.

[124] JMOOC Website < https://www.jmooc.jp/en/>.

[125] Khan Academy Website < https://www.khanacademy.org/>.

[126] Dhawal Shah, "By The Numbers: MOOCS in 2017," 2018.1.18. Class Central Website <https://www.class-central.com/report/mooc-stats-2017/>.

(2) Adaptive learning

COMPASS has developed a tablet for learning mathematics using AI. This tablet collects, accumulates, and analyzes the answers of the student, processes leading to the answers, speed, degree of concentration, and degree of understanding and then gives questions according to the student's level of understanding and strong and weak points, which facilitates efficient learning. The system contributed to the improvement of academic results in a trial experiment.[127]

(3) Learning mentors

Gakken Group provides a service in which a mentor (learning supporter) offers advice on teaching materials appropriate for the student based on data obtained from analysis results of the degree of understanding via AI using the academic results of the student as an input in the learning management system.[128] Surala Net has introduced a chat bot (automated conversation program) utilizing AI for its e-learning system to help learners maintain the motivation for learning and to improve their ability to concentrate by encouraging students according to their level of achievement.[129]

(4) Streamlining of the scoring process

To streamline the process of scoring answers to description type questions, a research group, which consists, for instance, of members from the University of California, has developed a system for recognizing the letters of hand-written answers and automating the scoring process of answers using AI.[130] In Japan, automated systems for scoring answers to description-type questions are being studied.[131]

4. Issues surrounding the application of AI and robotics in education

(1) Shortage of teachers and literacy

To utilize AI in schools, teachers who can use it must be first secured. However, in addition to mass retirement from the aging of society, other problems concern the shortage of teachers due to job changes among mid-career teachers[132] and long work hours[133] busyness among teachers and the shortage of teachers

---

[127] Ministry of Internal Affairs and Communications (ed.), *op.cit.* (45), p.199. <http://www.soumu.go.jp/johotsusintokei/whitepaper/ja/h28/pdf/n3300000.pdf>. (in Japanese)

[128] "What is the new self-reliant individualized learning G-PAPILS?" Gakken's new self-reliant individualized learning G-PAPILS Website <https://www.g-papils.com/about/>. (in Japanese)

[129] Shotaro Hamaguchi, "Supporting children with learning disabilities with e-learning, AI encouragement function," 2017.3.2. ITmedia Website <http://www.itmedia.co.jp/business/articles/1703/02/news141.html>. (in Japanese)

[130] gradescope Website <https://gradescope.com/>; Tony Kontzer, "Shares Professors of the World, Rejoice: Gradescope Brings AI to Grading," 2016.9.12. NVIDIA Japan Blog Website <https://blogs.nvidia.co.jp/2016/09/12/gradescope-brings-ai-to-grading/>. (in Japanese)

[131] Masayuki Kameda et al., Pprototyping JS[4] system for supporting the scoring of answers to short-answer description questions," *Proceedings of the Twenty-third Annual Meeting of the Association for Natural Language Processing*, 2017.3, pp.1137-1140. <http://www.anlp.jp/proceedings/annual_meeting/2017/pdf_dir/C7-1.pdf> (in Japanese); Rintaro Terada et al., "Automated scoring of answers to description type questions using neutral network," *Proceedings of the Twenty-two Annual Meeting of the Association for Natural Language Processing*, 2016.3, pp.370-373. <http://www.anlp.jp/proceedings/annual_meeting/2016/pdf_dir/A2-1.pdf> (in Japanese); Tsunenori Ishioka, "Automated grading of short essay," *Journal of the IEICE*, Vol.92 No.12, 2009.12, pp.1036-1040. <http://www.rd.dnc.ac.jp/~tunenori/doc/1036-1040.PDF>. (in Japanese)

[132] Rin Natsume, "Why is there a shortage of teachers?" 2017.8.14. Education Tomorrow <https://edutmrrw.jp/2017/innovation/0814_teacher_shortage>. (in Japanese)

[133] Central Council for Education's Committee for Basic Plan for the Promotion of Education, *op.cit.* (116), p.8. According to the 2013 OECD Teaching and Learning International Survey, the average working hours per week of a lower secondary school teacher

who can utilize ICT.[134] In terms of teachers' literacy regarding AI and ICT, 84.0% are at the level of "being able to utilize ICT for research of teaching materials and preparation of guidance," while 75.0% can "utilize ICT and teach during lessons," and 66.7% "can teach students how to use ICT" (all figures are national averages in 2017), which suggest that teachers skills in this area need improvement. However, the proportion of teachers who attended a "training program to improve teaching abilities utilizing ICT" was only 40.6% (2016 national average). [135]

(2) Establishment of ICT infrastructure and development of educational content

In terms of ICT infrastructure in schools, 6.2 students (national average) shared one computer for educational purposes as of March 2016.[136] Thus, environments for using ICT have not been sufficiently established. In terms of the introduction of so-called "digital school textbooks," there are issues associated with the establishment of ICT facilities and improvement of teachers' abilities to teach. In addition, there are institutional problems with paper-based school textbooks, such as the textbook authorization system and the system for the free provision of textbooks.[137]

(3) Credibility and safety of AI

Credibility and safety are some issues with the use of AI in the domain of education. In terms of credibility, for example, it is difficult for AI to understand natural languages and the meaning of sentences at this point.[138] Therefore, it is difficult for now for AI to perform interpretation and scoring for teachers without any help from people.

In terms of the issue of safety, program bugs (malfunctions) or security vulnerabilities may accidentally occur with highly complex AI, which may lead, for instance, to the loss or breach of personal information of students or cause robots to go out of control.[139] Technology to allow other AI to fix bugs is now being studied as a measure against such problems, although it will not be designed specifically for the domain of

---

in Japan was 53.9, which is the highest among the countries and regions that participated in the survey (the average of the surveyed countries and regions was 38.3).

[134] Japan Association for Promotion of Educational Technology (JAPET) & Microsoft Japan, "Survey of the use of ICT at school [data collection]," 2011, p.31. <http://www2.japet.or.jp/ict-chosa/ict_chosa_data.pdf>. (in Japanese)

[135] Ministry of Education, Culture, Sports, Science and Technology, "Results of the 2016 survey of situations of the informatization of school education (Summary) (as of March 2017), 2018.2, pp.23-25, 30. < http://www.mext.go.jp/component/a_menu/education/micro_detail/__icsFiles/afieldfile/2018/03/07/1399330_01.pdf> (in Japanese).

[136] Ministry of Education, Culture, Sports, Science and Technology, "Results of the 2015 survey of situations of the informatization of school education (Summary) (as of March 2016), 2016.10, p.2. <http://www.mext.go.jp/component/a_menu/education/micro_detail/__icsFiles/afieldfile/2016/10/13/1376818_1.pdf>. (in Japanese).

[137] Committee for reviewing the positioning of "digital textbooks," "Final report of the Committee for reviewing the positioning of 'digital textbooks'," 2016.12. <http://www.mext.go.jp/b_menu/shingi/chousa/shotou/110/houkoku/__icsFiles/afieldfile/2017/01/27/1380531_001.pdf>.(in Japanese)

[138] Noriko Arai, "Abilities required in the era when we coexist with AI: What has been revealed by Tou-robo's reading skills," 2017.6.28. Manabinoba.com Website <https://www.manabinoba.com/event_reports/016031.html>.

[139] Not an educational robot but a security robot in operation injured a child at a shopping center. Lilian Kim, "Parents upset after Stanford Shopping Center security robot injures child," *ABC NEWS*, 2016.7.11. <http://abc7news.com/news/parents-upset-after-stanford-mall-robot-injures-child/1423093/>.

education.[140]

Hideaki Iwahori, The University of Tokyo

V Hospitality

1. What is hospitality?

The number of those who work in the tertiary sector was 24,510,000 (46.6% of all employed workers) in 1970, but the figure increased to 39,620,000 (71.0%) in 2015 in Japan. The trend toward a service economy is expanding in terms of the employment structure.[141] A number of categories of businesses are included in the tertiary sector, and hospitality services are diverse. However, this chapter will discuss employment and labor in the lodging industry, food and beverage industry, sales industry (retail and wholesale), and leisure industry (entertainment industry), where the quality of hospitality significantly affects customer evaluations.[142] The number of employed workers has been decreasing for the past five years since 2010 in the lodging industry, food and beverage industry, wholesale industry, retail industry, livelihood-related service industry, and entertainment industry.[143]

2. Points of argument and issues pertaining to hospitality

(1) Increase of "mentality," such as *omotenashi*

Some note that "service" is used to refer to after-sales service or claim handling, but it now is blended with "*omotenashi*" or "hospitality," a concept based on the spirit of dedication. Here, not only uniform services appropriate for the price paid but also the degree of satisfaction and emotional aspects of those who receive hospitality are considered important.[144]

Sociologist Arlie R. Hochschild noted labor such as "*omotenashi*," in which workers are expected to regulate their emotions in accordance with the emotions of customers "emotional labor," as being among all the types of labor performed by workers.[145] Hochschild notes that as the added value of technology has decreased and become a commodity, businesses have begun to require this "*omotenashi*" of their workers as

---

[140] Joji Okada, "Can bugs be fixed automatically!? The present of automated program-fixing technology," 2016.4.14. NTT DATA Website <http://www.nttdata.com/jp/ja/insights/trend_keyword/2016041401.html> (in Japanese); Larry Hardesty, "Recognizing correct code: Automatic bug-repair system fixes 10 times as many errors as its predecessors," 2016.1.29. MIT News Website <http://news.mit.edu/2016/faster-automatic-bug-repair-code-errors-0129>.

[141] Ministry of Health, Labour and Welfare, *Analysis of the Labour Economy 2013 Summary*, 2013. < http://www.mhlw.go.jp/english/wp/l-economy/2013/dl/2013summary.pdf >; Bureau of Statistics, Ministry of Internal Affairs and Communications, "Summary of the results of the Basic Complete Tabulation on Working Conditions of the 2015 National Census of Japan," 2017.4.26, p.12. <http://www.stat.go.jp/data/kokusei/2015/kekka/kihon2/pdf/gaiyou.pdf> (in Japanese). The trend toward a service economy is seen not only in the employment structure by industry but also in the employment structure by occupation.

[142] Chiharu Iwai, "A consideration of politeness in materials for teaching hospitality," *Language and culture*, Vol.16, 2017.3, p.28. <http://repository.osakafu-u.ac.jp/dspace/bitstream/10466/15188/1/2016000205.pdf> (in Japanese).

[143] Bureau of Statistics, Ministry of Internal Affairs and Communications, "Summary of the results of the Basic Complete Tabulation on Working Conditions of the 2015 National Census of Japan," 2017.4.26, p.12. <http://www.stat.go.jp/data/kokusei/2015/kekka/kihon2/pdf/gaiyou.pdf> (in Japanese).

[144] Akira Yasuda, "Service and hospitality: Its genealogy and structure," *Hospitality Management*, Vol.2 No.1, 2011.3, pp.93-103. <https://ci.nii.ac.jp/els/contentscinii_20171203183407.pdf?id=ART0009827487> (in Japanese).

[145] A.R. Hochschild , *The Managed Heart: Commercialization of Human Feelings*, 1983.

added value, and she argues that this invisible labor has become a psychological burden for workers, introducing actual cases in the domains of hospitality, elderly care, and education.[146] Supporting this emotional labor with technology is expected to improve work environments.

(2) Utilization of AI and robotics in hospitality

With "functional service," it is easy to provide uniform service appropriate for the price paid and is easy to manualize such service, among various tasks in hospitality. Unlike this functional service, it is said that "emotional service," which creates customer satisfaction by providing *omotenashi* or making customers feel special, is a task that is difficult for AI to replace.[147] This is because responses must be considered in accordance with the context of each person, and goals must be explored through communication with the customers, among others. Having AI understand the context of individuals is an area still being developed even in today's AI technology. Expecting this to be solved in the next few years is not realistic.

Therefore, in the current situation, instead of replacing hospitality as it is, ways are now being explored to divide hospitality services traditionally provided by people into those that can be replaced by AI and robotics and those that people perform better in order to mechanize and automate the former type of hospitality services and have humans focus on the latter.[148]

3. Cases

(1) Automation through the introduction of vending machines

Vending machines can be referred to as "robots" that can provide services without human intervention. In recent years, vending machines equipped with image recognition or voice recognition functions have been installed. Among hospitality services that listen to customers' requests and take previously defined responses according to those requests in the sales business, those that do not require exceptional responses can be handled by vending machines set up with several request patterns. It is expected that the introduction of vending machines can reduce labor costs, allow 24-hour operation, and enable responses in multiple languages, such as English and Chinese.

As cases in Japan, convenience stores sell *onigiri* (rice balls) and *bento* (boxed lunch) using vending machines,[149] and McDonald has introduced an unmanned ordering machine at some of its stores.[150] In some business hotels, automated check-in and check-out machines have been installed. There are also some vending machines that show recommended products customized for each person through face recognition or voice recognition functions.[151]

---

146 Same as above.

147 Michael Chui et al., "Where machines could replace humans—and where they can't (yet)," 2016.7. McKinsey & Company Website <https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet>.

148 Hirotaka Osawa et al., "Analysis of Robot Hotel: Reconstruction of Works with Robots," *IEEE International Symposium on Robot and Human Interactive Communication*, 2017, pp.219-223.

149 "Vending machine convenience store (ASD), Family Mart Website <http://www.family.co.jp/company/asd.html> (in Japanese).

150 Daichi Goto, "McDonald increases sales growth and stock price with self-checkout machines," 2017.6.26. MyNavi News Website <https://news.mynavi.jp/article/20170626-a120/> (in Japanese).

151 Maki Miyamoto, "Vending machine with marketing brain shows up in Shinagawa Station, 47-inch touch panel operation," 2010.8.10. ITmedia Website <http://www.itmedia.co.jp/news/articles/1008/10/news080.html> (in Japanese).

(2) Unmanned operation through the introduction of human-like robots and mobile robots

Human-like robots and mobile robots with appearances that allow for closer interaction between machines and people have been introduced in airports and in the lodging industry. An accommodation facility called "Henn-na Hotel" represents a case where robots are used to provide hospitality services.[152] Robots perform tasks related to reception, cloakroom, luggage loading, cleaning, and concierge services. Because people handle customers when robots cannot handle them alone, the hotel can keep the number of employees and labor costs low.[153]

At "Henn-na Hotel," robots also replace humans in performing not only "functional services," such as check-in procedures, but also greeting and concierge services as an attempt to replace "emotional services." At this point, the level sufficient to replace emotional services of humans has not yet been achieved, but we can expect a reduction of "emotional labor" associated with employees' "emotional services" from having robots take a central role in hospitality and having employees assist them.[154] On the other hand, it has been noted that employees using robots or working together with robots need to understand the structure of robots, and they need skills in giving instructions to robots without doing the actual tasks (reception or cleaning) that robots do and in making evaluations and judgments. Customers may also need literacy (understanding and readiness) as to how they should handle interactions with robots.

4. Issues

The following issues are noted in relation to the introduction of AI and robotics in hospitality.

(1) Technological issues and establishment of the environment

The advantage of using AI and robotics in hospitality is the capability of providing customized hospitality services to individuals: however, there are still some problems regarding the recognition accuracy of customers' likeness and voice. For example, voice recognition technology has improved from the separation of sound sources of speakers using multiple microphones and the accumulation of vast volumes of data using smart phones, but there are still problems when it comes to recognizing conversations in a real-life environment where conversations of multiple people and noises exist.[155] The technology sometimes cannot recognize information correctly due to biased data learned by AI, in which cases people need to provide assistance.

It is also necessary to create an environment where robots can easily move around, in terms of human-like robots and mobile robots. "Henn-na Hotel" is a totally barrier-free facility so that robots can move around easily within the building. There is a Japanese inn that invested 70,000,000 yen to reduce the food-serving burden of room attendants and introduce an automated food serving system.[156]

---

[152] AIR, "A visit to "Henn-na Hotel": Ever-changing workplace," *Information Processing*, Vol.57 No.11, 2016.10, pp.1078-1083 (in Japanese). "Henn-na" means "Wired."

[153] ""Henn-na Hotel" providing robot hospitality will go global, Second hotel will be built in Maihama, Chiba, The next ones will be in Osaka and Nagoya near popular theme parks," 2016.8.4. Travel Voice Website <https://www.travelvoice.jp/20160804-71802> (in Japanese).

[154] AIR, *op.cit.* (152).

[155] See "IV Speech User Interface" of Part 1 of this report.

[156] Sadahiko Oda, "*Omotenashi* of long-established Japanese inn "Kagaya" supported by robots," *Chuo Koron*, Vol.130 No.4, 2016.4, pp.89-94 (in Japanese). In Japan, some *ryokan* (luxurious inn) provides dinner room service.

(2) Privacy

It is necessary to be careful with privacy when storing dialogues with customers over a long period of time to improve the quality of hospitality.[157] In particular, the "recommendation" function has been already realized in internet ads, for instance, using stored data, but there exists an issue of privacy. For example, a supermarket in the US that analyzed the purchase history of a teenage girl as "predicted pregnancy" and "recommended" products related to pregnancy became problematic. It turned out later that she was actually pregnant.[158]

Thus, when AI describes a person based on his or her purchase history (e.g., profiling), businesses can obtain information about the person's status and taste, but other people may also obtain such information through displayed ads. In relation to this problem, the General Data Protection Regulation (GDPR),[159] which was adopted in 2016 to reinforce the protection of personal data in the EU and will come into effect on May 25th, 2018, will include "the right not to be subject to profiling.

(3) Reconsideration of values provided through "hospitality"

When machines replace some hospitality services, workers will be free of "emotional labor" but may have fewer opportunities to receive "gratitude" or "smiles" from customers.[160] Some tasks may be replaced by robots, but there may be some value that only humans can provide. Therefore, when introducing AI and robotics in hospitality, it will be important to clarify what kind of value they should offer customers, what tasks will be performed by robots, and what will be done by humans.

Hirotaka Osawa, University of Tsukuba
Arisa Ema, The University of Tokyo

VI Transportation/Mobility

1. Shortage of drivers in the transport industry and related issues

Due to the expansion of demands for e-commerce services using the internet, the number of parcels handled by package delivery services has been steadily growing recently, reaching 4.02 billion in 2016, an increase of 270 million parcels (7.3%) from the previous year in Japan.[161] In the road freight transport industry, the wage level is relatively low compared to the average among all industries, but the work

---

[157] AIR, *op.cit.* (152).

[158] Kashmir Hill, "How Target Figured Out A Teen Girl Was Pregnant Before Her Father Did," *Forbes*, 2012.2.16. <https://www.forbes.com/sites/kashmirhill/2012/02/16/how-target-figured-out-a-teen-girl-was-pregnant-before-her-father-did/>.

[159] "REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)," *Official Journal of the European Union*, L119, 2016.5.4, pp.1-88. <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN>.

[160] AIR, *op.cit.* (152).

[161] Logistics Policy Planning, Logistics Policy Division, Cargo Transport Division, Road Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "About the number of parcels delivered in 2016," 2017.7.28. Ministry of Land, Infrastructure, Transport and Tourism Website <http://www.mlit.go.jp/report/press/jidosha04_hh_000136.html> (in Japanese).

environment is poor; truck drivers have to work long hours, and the industry is aging.[162] To address this issue in the private sector, Yamato Transport reported to withdraw from the same day delivery service of Amazon, an internet shopping giant.[163] The work environment of bus drivers and taxi drivers, including the wage level and working hours, is also worse than the average among all industries.[164]

Against this background, a shortage of drivers is becoming a problem, as over half of the drivers in the transport industry (truck, bus, and taxi) in Japan have felt a manpower shortage.[165] There is a concern that the shortage of drivers and the work environment in the transport industry may worsen in the future due to population aging and the declining birthrate. Some note that the mass transportation system may decay mainly in rural areas, which will result in a reduction in means of transportation for the elderly.[166] "Last one mile"[167] has become a problem here in relation to the redelivery of parcels and mobility from the closest station to home.

2. Reduction of drivers' burden and the operation of new mobility services

To improve the work environment of drivers, the Ministry of Health, Labour and Welfare formulated the "standard for improving working hours" of bus, truck, and tax drivers.[168] In addition, technologies are now being developed to determine whether drivers are in a state fit to safely drive based on their sleepiness and smart phone use through "driver concentration sensing technology."[169]

To address the shortage of drivers, there have been discussions on unmanned operations using self-driving vehicles. To realize self-driving vehicles, the Cabinet Office formed the "Committee for promoting automated driving system" in 2014, and the Ministry of Land, Infrastructure, Transport and Tourism, Ministry of Economy, Trade and Industry, Ministry of Internal Affairs and Communications, and National Police Agency have been conducting research and development and discussing institutions related.[170] The Cabinet Office's "Cross-ministerial Strategic Innovation Promotion Program (SIP) cites "automated driving systems" as one of the issues. The program is working not only on developing technology related to self-driving cars but also on creating high-accuracy maps for achieving high-accuracy position estimation. It is

---

[162] Japan Trucking Association, "Japan's truck transport industry, Current status and problems 2017," 2017.8, p.15. <http://www.jta.or.jp/coho/yuso_genjyo/yuso_genjo2017.pdf> (in Japanese).

[163] "Yamato withdraws from same day delivery service, Yamato's direction, turning point for online shopping", *Nihon Keizai Shimbun*, 2017.4.7, p.1 (in Japanese).

[164] "2016 current statuses of wages and working hours of taxi drivers," 2017.4.18, p.7 (Table 7). Japan Federation of Hire-Taxi Associations Website <http://www.taxi-japan.or.jp/pdf/toukei_chousa/tingin28.pdf> (in Japanese).

[165] Ministry of Health, Labour and Welfare(ed.), *2017 White Paper on Measures to Prevent Karoshi, etc.*, 2017, pp.4. „< http://fpcj.jp/wp/wp-content/uploads/2017/11/8f513ff4e9662ac515de9e646f63d8b5.pdf >.

[166] Yusuke Ikeda, "Current statuses of self-driving technology, etc.," *Jurist*, No.1501, 2017.1, p.16 (in Japanese).

[167] "Last one mile" (last mile in English) means the route from the closest distribution center to the client in parcel delivery and the route from the closest station or bus stop to home in mobility. Even if there are no problems in getting to the distribution center or the closest station, there may be redelivery within the last section or a loss of means of transportation except on foot.

[168] "Standards for improving working hours of vehicle drivers," Ministry of Health, Labour and Welfare Website <http://www.mhlw.go.jp/stf/seisakunitsuite/bunya/koyou_roudou/roudoukijun/gyosyu/roudoujouken05/index.html> (in Japanese).

[169] OMRON Corporation, "Developing the world's first 'leading-edge AI-equipped vehicle-mounted censor'," 2016.6.6. OMRON Website <http://www.omron.co.jp/press/2016/06/c0606.html> (in Japanese).

[170] Masahiro Kobayashi, "Legislative issues toward realization of autonomous vehicles," *Journal of information processing and management*, Vol.60 No.4, 2017.7, p.241. <https://www.jstage.jst.go.jp/article/johokanri/60/4/60_240/_pdf/-char/ja> (in Japanese).

also conducting research on rules related to mutual recognition and communication among drivers, vehicles, and pedestrians[171] and an empirical experiment related to truck "platooning" on highways.[172]

3. Cases

Unmanned operations using self-driving cars (fully automated driving) are still at the stage of empirical experiments. However, transportation and mobility services using smart phone apps and IoT are now being introduced as measures for addressing last mile, and they are expected to streamline the tasks of transportation and mobility.

(1) Vehicles for ride share using AI

Empirical experiments for enabling AI to predict mobility demands in real-time and allocating vehicles (buses, taxis) available for ride sharing according to demand without fixing routes are being conducted; it is assumed that the allocation of unmanned self-driving cars may become a reality in the future.[173] This will allow drivers to drive their cars according to demand while reducing vacant driving and time waiting for passengers; thus, it is expected to reduce drivers' burdens.

(2) Delivery of parcels using IoT when the receivers are away

In November 2017, Amazon launched a service in the US for delivering parcels to homes when receivers are away, using an IoT device (smart lock) to open and lock the front door of homes via the internet.[174] In Japan, Linough, Inc. announced that it will launch parcel delivery and housekeeping services using smart lock in February 2018, which is expected to solve the issue of redelivery.[175] This service lets other people in the house. Therefore, it will use a cloud camera to check images around the front door of a house from a smart phone and another indoor door with a lock installed in the back of the front door to ensure security.[176]

(3) Drones

The Civil Aeronautics Act (Act No. 231 of 1952) was amended in 2015, stipulating rules regarding permission and application when flying unmanned aerial vehicles and flying-allowed zones. In 2015, the

---

[171] Director General for Science, Technology and Innovation, Cabinet Office, "Cross-ministerial Strategic Innovation Promotion Program (SIP) Research and development plan of self-driving system," 2017.9.28. <http://www8.cao.go.jp/cstp/gaiyo/sip/keikaku/6_jidousoukou.pdf> (in Japanese).

[172] "We will begin the world's first experiment of truck "platooning" on highways using CACC: Empirical experiment of truck "platooning" on highways to realize mobility revolution," 2018.1.12. Ministry of Economy, Trade and Industry Website <http://www.meti.go.jp/press/2017/01/20180112002/20180112002.html> (in Japanese).

[173] Mirai Share, "Spread of a new transportation service using Smart Access Vehicle (SAV)," 2017.3. Ministry of Economy, Trade and Industry, Hokkaido Bureau of Economy, Trade and Industry Website <http://www.hkd.meti.go.jp/hokim/20170217/data05.pdf> (in Japanese).

[174] Joan E. Solsman, "Amazon Key hack could make you clueless in a home invasion," 2017.11.16. CNET Website < https://www.cnet.com/news/amazon-key-hack-camera-security/ >.

[175] "Project 'Service coming into home' even when you are away from home is launched in "Genia Omori-nishi" in Ohta-ku, Tokyo, [Japan's first rental apartment cooperating with parcel delivery and housekeeping services], Partnering with 5 businesses, including PalSystem," 2018.1.30. Linough Website <https://linough.com/> (in Japanese).

[176] Wakako Mukohata, "Can this be Japanese version of Amazon Home>? New project using smart lock so that you can receive parcel delivery and housekeeping services even when you are away from home," 2018.1.30. TechCrunch Website <http://jp.techcrunch.com/2018/01/30/linough-starts-the-project-for-secure-delivery-and-house-keeping-services-while-not-at-home/> (in Japanese).

Ministry of Land, Infrastructure, Transport and Tourism began discussions regarding the realization of parcel delivery using drones as early as 2018 to address the shortage of manpower in the transport industry.[177] Drones are expected to be used not only in urban areas but also in remote island areas and underpopulated areas, at times of disaster, and for freight transport within warehouses.[178]

In 2015, experiments were carried out for transporting drugs and medicine (supposedly) and for performing disaster surveillance in Kannonji City, Kagawa Prefecture, as part of the "Setouchi Kamome Project," in which private businesses are studying the use of drones in remote island areas, secluded areas, and mountainous areas.[179]

On the other hand, because the weight should be limited to about 10 kilograms when using drones for transportation, economic feasibility[180] is considered one of the issues, in addition to the problem of noise.[181] The "Council for establishing an environment for flying drones via government-private sector collaboration," which consists of officials of relevant ministries and personnel of relevant industries, has presented a road map for the future in relation to the development of technology and establishment of the related environment with the assumption of aerial vehicles flying without pilots or any assistance in order to promote the use of drones.[182]

4. Issues

(1) Legal issues

In local areas, ride-share services using private vehicles are anticipated as a means of transportation that will complement public transportation.[183] However, because the Ministry of Land, Infrastructure, Transport and Tourism noted that such services may be in violation of the Road Transportation Act (Act No. 183 of 1951),[184] which prohibits so-called "unlicensed taxi" services, these ride-share services are provided only in secluded areas at this point as an exception.[185] On the other hand, ride-share services where drivers receive only the actual expenses from users are considered outside the scope of the act,[186] and therefore, people are paying attention to how the services are going to expand in the future.

---

[177] Ministry of Land, Infrastructure, Transport and Tourism, "Use of drones in the domain of logistics," Ministry of Land, Infrastructure, Transport and Tourism Website <http://www.mlit.go.jp/seisakutokatsu/freight/seisakutokatsu_tk_000024.html> (in Japanese).

[178] Logistics Policy Division, Policy Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "2015 Report of tasks including surveys pertaining to the use of drones in logistics," 2016.3, pp.6-7. <http://www.mlit.go.jp/common/001136816.pdf>.

[179] Same as above, pp.19-20 (in Japanese).

[180] "Drone logistics, issue of economic feasibility," *Mainichi Shimbun* (western region version), 2017.9.2, p.22 (in Japanese).

[181] Jin Kodama, "NASA research "Noises of drones put more stress on human than cars, Measures against noise is necessary of the wide use of drones," 2017.7.20. roboteer Website <https://roboteer-tokyo.com/archives/9727> (in Japanese).

[182] Council for establishing an environment for flying drones via government-private sector collaboration, "Roadmap for industrial revolution in the air: Technological development and environment establishment for safe use of drones," 2016.4.28. < http://www.meti.go.jp/english/policy/mono_info_service/robot_industry/downloadfiles/uasroadmap.pdf >.

[183] For example, "Effective use of the internet to make local transportation more convenient," *Nihon Keizai Shimbun*, 2015.12.1, p.2 (in Japanese).

[184] "MLIT orders share-ride services to stop operations for providing possible unlicensed taxi service in Fukuoka's experiment," *Nihon Keizai Shimbun*, 2015.3.5, p.38 (in Japanese).

[185] In Tango City, Kyoto Prefecture, the service is operated based on the "fare-paying conveyance of passengers in areas where no public transportation is available," as defined in Article 49, Section 1 (2) of Ordinance for Enforcement of the Road Transportation Act (Ordinance of the Ministry of Transport No. 75 of 1951. "What is "mutual support transportation"?" Kibaru! Furusato Tango-cho Website <http://kibaru-furusato-tango.org/about-sasaeai/> (in Japanese).

[186] The ride-share service is operated in Nakatombetsu, Hokkaido, as a fare exempt from the Road Transportation Act. "Experiment of Nakatombetsu share-ride project," 2017.8.21. Nakatombetsu-cho Website

Ride-share services using private vehicles are performed by the driver of the private car who signed a contract with the service provider. Issues related to the legal rights and obligations of contracted drivers have been noted, such as the issue of safety management associated with the responsibility taken by the contracted driver,[187] not by the service provider, and the issue of the provision of welfare benefits to contracted drivers.[188]

In terms of self-driving cars, civil and criminal liability[189] in the event of an accident and insurance systems[190] are considered problems.[191]

(2) Privacy

The issue of privacy can occur when it comes to private information associated with people's movement. For example, the providers of mobility services may keep or use the location information of users, which raises concerns regarding the invasion of privacy

Drones equipped with cameras can also recognize certain people based on images taken from the air, which also raises concern regarding the invasion of privacy. The Ministry of Internal Affairs and Communications has warned about the handling of images taken by drones on the internet.[192]

Arisa Ema, The University of Tokyo

VII Agriculture

1. Dealing with the shortage of agricultural workers and the use of AI and robotics

(1) Dealing with the shortage of agricultural workers

In the "Basic Plan for Food, Agriculture and Rural Areas" (Cabinet decision on March 31, 2015), six perspectives are provided in relation to the current perception of food, agriculture, and rural areas: (1) the effects of aging and population decline on food, agriculture and rural areas; (2) the prospects of global food

---

<http://www.town.nakatombetsu.hokkaido.jp/docs/2016081800017/> (in Japanese). See the following material as well: Ministry of Economy, Trade and Industry, "Handling of the Road Transportation Act in relation to mid- to long-distance share-ride matching services has been clarified: Use of the System to Eliminate Regulatory Gray Zones in Act on Strengthening Industrial Competitiveness, "2017.5.18. Ministry of Economy, Trade and Industry Website <http://www.meti.go.jp/press/2017/05/20170518001/20170518001.html> (in Japanese).

[187] Yoshio Tsukuda, "Obstacles hindering the spread of 'share-ride'," 2016.8.12 Yomiuri Online <http://www.yomiuri.co.jp/fukayomi/ichiran/20160810-OYT8T50091.html?page_no=2> (in Japanese).

[188] David Priest, "Uber gives in, grants some benefits to British drivers," 2017.4.27. CNET Website <https://www.cnet.com/news/uber-brings-benefits-to-british-drivers/ >.

[189] For example, "Feature: Autonomous driving and civil liability," *Jurist*, No.1501, 2017.1, pp.13-55; Yuka Nakagawa, "Criminal liability of drivers and manufacturers pertaining to autonomous driving: Problems arising from the introduction of autonomous driving and future directions," *Chukyo Lawyer*, No.27, 2017.9, pp.15-29. <https://www.chukyo-u.ac.jp/educate/law-school/chukyolawyer/data/vol027/02_nakagawa.pdf> (in Japanese).

[190] For example, General Insurance Association of Japan New Risk PT, "About legal issues of autonomous driving," 2016.6. <http://www.sonpo.or.jp/news/file/jidou_houkoku.pdf> (in Japanese).

[191] *Trends and problems of autonomous driving technology: 2017 report of the project for investigating science and technology* (Survey material 2018-4), National Diet Library, 2018 (in Japanese), addresses technological trends related to autonomous driving and its various issues.

[192] Ministry of Internal Affairs and Communications, "Warning about the handling of images on the internet taken by drones from the air," 2015.4.28. Ministry of Internal Affairs and Communications Website <http://www.soumu.go.jp/menu_kyotsuu/important/kinkyu02_000189.html> (in Japanese).

supply and demand as well as progress of globalization; (3) the diversification of issues concerning the relationship between consumers and food; (4) changes in the structure of agriculture and rural areas, including farmers who support agriculture; (5) diverse possibilities of agriculture and rural areas; and (6) the status of restoration/reconstruction from the Great East Japan Earthquake.[193] Agriculture is closely linked with the maintenance and management of farm lands and agricultural water, food processing, and distribution, but in this chapter will focus on employment and labor associated with the production of crops and livestock raising.

While there are various types of agriculture, such as rice growing, dry-field farming, dairy farming, livestock raising, and fruit farming, the labor force required varies by period. Farmers need to hire a massive labor force during the harvesting season of seasonal crops in particular.[194] Because many of the tasks are based on experience or intuition, it takes a considerable amount of time for new farmers to become effective workers.[195] The number of core persons mainly engaged in farming, whose daily job is farming, among the population engaged in farming has decreased by 22% (from 2,240,000 to 1,750,000) over the past 10 years. The number of regular workers hired for a period of over 7 months increased 1.6 times (from 61,094 to 99,393), but the agricultural labor force is shifting from household members (e.g., relatives who live in the same household) to employees.[196]

To address the labor force shortage caused by the aging of farmers and people leaving farming, the Ministry of Agriculture, Forestry and Fisheries is working of securing new farmers, mainly young people, by supporting them through training programs before they become farmers and supporting the establishment of businesses after they become farmers as a project for investing in next-generation farmers. This has apparently paid off.[197] In 2016, the number of new farmers exceeded 60,000 for the first time in 6 years, and the number of new farmers aged 49 or younger was the highest since 2007.

(2) Establishment of an environment toward the use of AI and robotics

AI and robotics are anticipated as new measures for complementing the labor force shortage and improving labor productivity.[198] Safety is also expected to improve by using AI and robotics in dangerous tasks, such as pesticide spraying on slopes or mowing.[199]

In 2013, the Ministry of Agriculture, Forestry and Fisheries formed the "Study group for achieving smart agriculture,"[200] with cooperation from robotics and IT businesses, farm equipment manufacturers, and relevant ministries, to discuss methods for promoting the use of AI and robotics in agriculture (smart

---

[193] Summary of the Basic Plan for Food, Agriculture and Rural Areas (Cabinet decision on March 31, 2015). Ministry of Agriculture, Forestry and Fisheries of Japan Website < http://www.maff.go.jp/e/policies/law_plan/attach/pdf/index-2.pdf >.

[194] Sumito Yasuoka, "Promotion of smart agriculture," *Journal of the Robotics Society of Japan*, Vol.35 No.5, 2017.6, p.362.

[195] Ministry of Agriculture, Forestry and Fisheries of Japan, "About acceleration of smart agriculture using AI and IoT (draft), (Fifth meeting of the study group for achieving smart agriculture, material 3-1), 2016.11, p.2. <http://www.maff.go.jp/j/kanbo/kihyo03/gityo/g_smart_nougyo/attach/pdf/kenkyu_kai05-6.pdf> (in Japanese).

[196] Ministry of Agriculture, Forestry and Fisherie, *Summary of the Annual Report on Food, Agriculture and Rural Areas in Japan*, 2017.5, p.6. < http://www.maff.go.jp/e/data/publish/attach/pdf/index-57.pdf>.

[197] Same as above, pp.6, 17.

[198] Same as above, p.16.

[199] Kenji Imou, "Automation of bio production machinery and the use of robotics," *Journal of the Robotics Society of Japan*, Vol.35 No.5, 2017.6, p.378 (in Japanese).

[200] Ministry of Agriculture, Forestry and Fisheries of Japan, "Study group for achieving smart agriculture," Ministry of Agriculture, Forestry and Fisheries of Japan Website <http://www.maff.go.jp/j/kanbo/kihyo03/gityo/g_smart_nougyo/index.html> (in Japanese).

agriculture) and to devise guidelines. In November 2016, the study group sorted out the possibilities of using AI and robotics to address problems facing agriculture. To address the decline in the number of farmers and labor force shortage, it laid out a direction to promote efforts (1) to promote significant labor saving through the use of robots for various tasks and (2) to encourage the use of farming practices in which anyone can easily engage (through the introduction of a system where people can learn the know-how of experienced farmers in a short period of time and conduct image analysis of disease and pests).[201]

2. Cases

(1) Autonomous vehicles, fruit and vegetable harvesting robots, and drones

Autonomous vehicles made with conventional agricultural vehicles, such as tractors, rice planters, and combines, equipped with location measuring equipment and self-steering equipment have not yet been widely accepted, not because of technical problems, but because a system concerning liability in the event of accidents has not been fully established.[202]

In terms of fruit and vegetable harvesting robots, for example, strawberry harvesting robots need to move on a rail within the facility, and they cannot be introduced to existing facilities. Therefore, some note that it is necessary to design entire facilities, not just robots, on the assumption that robots will be doing growing and harvesting tasks.[203] Studies have also been conducted on a cultivation method for making tree forms straight so that robots can be utilized at low cost.[204] Either way, the work speed is slower than that with human workers, and robots are expensive; accordingly, these methods remain at the experimental phase at this point.[205]

In terms of drones, technology has been developed for automatically measuring the growth level and detecting disease and pests, which have been conventionally performed by humans with the use of airborne images and image recognition technology. Such technology will allow tasks to be streamlined.[206] Pesticide spraying using drones has been carried out in Japan since the 1980s; it has been estimated that the number of registered drones for such purposes in Japan exceeds 2,500.[207]

(2) Gathering, analysis, and use of agricultural information through the cloud

Cloud services can make agriculture easy for anyone to engage in by gathering, analyzing and using mobile devices and sensors and visualizing the experience of experienced farmers. For example, Fujitsu's "Akisai" cloud for the food and agricultural industry helps to increase the yield ratio by thoroughly enforcing tasks at proper times, to reduce total work hours through analysis of work processes, to allow farmers to receive advice from farming management advisers, and to predict the emergence of disease and pests. In the future, Fujitsu is looking to establish an efficient production model based on the accumulation and analysis

---

201 Ministry of Agriculture, Forestry and Fisheries of Japan, *op.cit.* (196)
202 Imou, *op.cit.* (199), p.377.
203 Same as above.
204 Yasuoka, *op.cit.* (194), p.365.
205 Naoshi Kondo, "Sensing and robot technology in food production facilities for the era of 9 billion people," *Journal of the Robotics Society of Japan*, Vol.35 No.5, 2017.6, p.381 (in Japanese).
206 Aya Sugiura, "High-speed field phenotyping through drone airborne images," *Journal of the Robotics Society of Japan*, Vol.35 No.5, 2017.6, p.369 (in Japanese).
207 Shinji Suzuki, "Technological and institutional directions for the safe use of drones," *Journal of the Robotics Society of Japan*, Vol.34 No.1, 2016.1, p.24. <https://www.jstage.jst.go.jp/article/jrsj/34/1/34_34_24/_pdf/-char/ja> (in Japanese).

of data, to standardize information, and to make data open.[208] The system is expected to allow new farmers to engage in tasks with a sense of security by allowing them to use objective data.

(3) Cattle feeding management and ranch operation management using wearable devices

Farmnote, an IT venture in Hokkaido, developed a wearable device called "Farmnote Color," which is put on a cattle's neck and gathers data in real time. "Farmnote Color" gathers the behavioral data of cattle, analyzes it using AI, identifies the estrus symptoms or diseases of cattle, and automatically sends information regarding abnormal cattle and the like to smartphones and similar devices.[209] The company provides "Farmnote," which is a cattle population management system using "Farmnote Color", to farmers. Over 2,000 farmers already use the system.[210] The company also holds seminars to contribute to the formation of farmers' community their systems.[211] The cattle population management system has a ranch operation management function, and it is capable of visualizing financial health, sales, cost and allows multiple people to communicate with each other in real time.[212]

3. Points of argument over the use of AI and robotics in agriculture

(1) Establishment of an environment for facilitating the use of data

To use the data obtained from wearable devices and images in actual workplaces, it is necessary to use mobile devices, such as smartphones, to record and view data.[213] To do so, it is important to secure a certain level of communication speed even in rural areas and to establish a communication environment for accessing the cloud. To predict or analyze growth, a certain amount of data must be accumulated. However, there are some types of data that can be obtained only in certain seasons, such as in rice growing and horticulture. How data necessary for prediction and analysis should be gathered can be a point of argument.

(2) Establishment of institutions for the use of AI and robotics

As introduced in the concrete case section, while the technology exists, it has not been widely disseminated due to delays in the establishment of institutions. Therefore, it is necessary to establish the required environment for the use of AI and robotics in the domain of agriculture. In 2017, the Ministry of Agriculture, Forestry and Fisheries formulated the "Guidelines for ensuring safety of robotic equipment for agriculture," stipulating matters that should be respected by manufacturers and users to ensure safety, with consideration of the practical realization of agricultural machines equipped with robot technology (robotic

---

[208] Akihisa Kamata, "Fujitsu's efforts toward agricultural ICT: To create agri-industry" (Growth Strategy Council -Investing for the Future, Meeting for the "deepening of local Abenomics (agriculture) (5th meeting) (February 6, 2017) Material 3," 2017.2.6, pp.5-6, 11. Office of Prime Minister Website <https://www.kantei.go.jp/jp/singi/keizaisaisei/miraitoshikaigi/suishinkaigo_dai5/siryou3.pdf> (in Japanese).

[209] "Farmnote, launches 'Farmnote Color,' a wearable device for cattle using AI," 2016.8.5. <https://farmnote.jp/press-release/farmnote-color2016.html> (in Japanese).

[210] Farmnote Website <https://farmnote.jp/index.html> (in Japanese).

[211] For example, "Farmnote Summit 2016: Be Connected," 2016.11.16. Farmnote Website <https://farmnote.jp/events/summit2016.html> (in Japanese).

[212] "Announcing the latest version of cattle management system 'Farmnote 2.0,' for 'easy' optimal management of ranch using smart device," 2015.4.13. Farmnote Website <https://farmnote.jp/press-release/20150413.html> (in Japanese). During the interviews conducted by the author with users of Farmnote (on July 16, 2017), some noted that financial health is presented with numerical values, and therefore, they can propose improvements even if they are not experienced.

[213] Both the "Akisai" cloud for the food and agricultural industry mentioned earlier and "Farmnote" have a system that can be installed on smartphones so that users can view the status on farms and ranches.

equipment for agriculture) that can drive autonomously or automatically perform tasks.[214] Under the Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society (IT Strategic Headquarters), guidelines are now being prepared regarding the standardization and handling of agricultural information toward the proper use of agricultural big data.[215]

(3) Adaptation to the needs of farmers and the environment

AI and robot technologies and devices for agriculture are now being studied and developed not only by agricultural industry personnel but also through collaboration between experts of leading-edge technology in information science and engineering and private companies, including ventures. However, we need to ensure that the performance of products developed based on engineering expertise matches the performance demanded in actual agricultural workplaces. For example, there is a concept called "proper farming at proper timing" in agriculture, and there are some crops that must be harvested all at once within a few days depending on the weather. It is unacceptable if agricultural equipment that has not been used for several months does not work during this period. We must note that agricultural equipment must properly function and must be able to be fixed by users when malfunctions occur, even if this is not a cutting-edge technology but an old technology that is a prerequisite for agricultural equipment.[216]

Arisa Ema, The University of Tokyo

VIII Public Order and Security

1. Current situation concerning public order and security in Japan

In 2016, the number of police officials was 295,000. Of these, 7,797 were employees of the National Police Agency, and 287,000 were employees of prefectural police departments. The number of recognized criminal offenses has been on the decline for 13 consecutive years since 2003. However, the number of crimes in which women and the elderly are victims, such as stalking and violence from spouses, and the number of crimes involving special fraud are very high. The increase in international terrorism and rise in cybercrimes are also becoming problems.[217]

In terms of cybercrimes, the number of victims of illegal money transfers using internet banking is decreasing, but "targeted email attacks," which involve the theft of information of certain targeted organizations or individuals, are on the rise. The number of arrested persons and number of arrests due to

[214] Ministry of Agriculture, Forestry and Fisheries of Japan, "Guidelines for securing safety of autonomous driving of agricultural equipment," 2017.3. <http://www.maff.go.jp/j/kanbo/kihyo03/gityo/g_smart_nougyo/attach/pdf/index-2.pdf> (in Japanese).

[215] "Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society (IT Strategic Headquarters) Report of expert panel on promotion of new strategies," Office of Prime Minister Website <https://www.kantei.go.jp/jp/singi/it2/senmon_bunka/nougyou.html> (in Japanese).

[216] Yohei Hoshino, "Efforts toward industry-agriculture cooperation: Damping control of boom sprayers and robot technology," *Journal of the Robotics Society of Japan*, Vol.35 No.5, 2017.6, p.392 (in Japanese).

[217] National Police Agency (ed.), Police White Paper 2017, 2016, p.53. < https://www.npa.go.jp/hakusyo/h28/english/WHITE_PAPER_ON_POLICE_2016/full_text_WHITE_PAPER_2016_.pdf >.

unauthorized access are both the highest since the enactment of the Act Concerning the Prohibition of Unauthorized Computer Access (Act No. 128 of 1999).[218]

The decrease in the number of those who take the police officer recruitment test due to the declining birthrate and mass retirement in the field due to population aging are problems that Japan's police organizations will have to face over a long period of time. Police departments are actively involved in increasing the number of local police officers and hiring and using retired police officers or female police officers, but streamlining tasks is an issue.[219] It is also estimated that there is a shortage of about 130,000 people handling information security as of 2016.[220] Since the shortage of people in information security and the lack of highly advanced skills among them are becoming issues,[221] police organizations are promoting personnel exchanges and information sharing with private businesses.[222]

2. Utilization of AI in maintaining and ensuring security

It is still difficult to secure human resources even though there have been various efforts. To ensure order and security, various discussions have been held regarding the use of AI, robotics, and related technologies under the perception that it is important not only to make arrests after the fact but also to prevent crimes based on indications of crimes and to streamline security tasks. In addition to efforts toward the use of AI to identify and track crimes, it is important to made efforts to save labor and automate security tasks and processes using drones and automated monitoring and detection systems and to perform "predictive policing" in order to prevent crimes in advance.

(1) Identifying and tracking crimes

There are cases where criminals are identified and tracked using images gathered through surveillance cameras. For instance, the New York City Police Department has introduced a system for cross-checking the images of criminals with images gathered through surveillance cameras and social media using a facial recognition system.[223] Republic of Korea (ROK) is also planning to introduce a system for detecting traffic accidents and crimes in real time or for tracking suspects and cars using AI.[224]

---

[218] National Police Agency, "About cyber threat landscape in 2016," 2017.3.23, p.1. <http://www.npa.go.jp/publications/statistics/cybersecurity/data/H28cyber_jousei.pdf>. (in Japanese).

[219] Same as above, pp.198-199.

[220] Information Services Industry Division, Commerce and Information Policy Bureau, Ministry of Economy, Trade and Industry, "Summary of the report: Results of the survey of the latest trend and future estimation of IT human resources," 2016.6.10, p.12. <http://www.meti.go.jp/policy/it_policy/jinzai/27FY/ITjinzai_report_summary.pdf>. (in Japanese).

[221] National Police Agency Conference on Comprehensive Security Measures, "Human resources development for addressing cybercrimes through government-industry collaboration: Report of the 2014 Conference on Comprehensive Security Measures," 2015.3, p.6. <https://www.npa.go.jp/cyber/csmeeting/h26/pdf/h26_honpen.pdf>. (in Japanese).

[222] National Police Agency (ed.), *op.cit.* (217), pp.41-43. < https://www.npa.go.jp/hakusyo/h28/english/WHITE_PAPER_ON_POLICE_2016/full_text_WHITE_PAPER_2016_.pdf >.

[223] Koji Hachiyama, "Current situations of efforts of crime prevention, security, and IT in US," 2015.11, p.6. <https://www.jetro.go.jp/ext_images/_Reports/02/cb0c9a0b7b7e9c15/rpNY_201511.pdf>. (in Japanese).

[224] "Connecting with the police databases, Korea introduces "AI-equipped monitoring cameras in 2018," 2017.6.5. Roboteer Website <https://roboteer-tokyo.com/archives/8979>. (in Japanese).

It was reported by the media that the Durham Police in the UK will introduce a crime risk assessment AI called "Harm Assessment Risk Tool (HART), which analyzes the severity of crimes and risks of suspects and determines whether suspects need to be detained based on data regarding past crimes and the like.[225]

(2) Security and investigations using drones

Drones are used to save labor and automate the implementation of security and related processes. At the Ise-Shima Summit held in 2016, two types of drones were prepared: those for aerial photography and those for preventing drone-based terrorism attacks. If suspicious objects flew by around the venue, the former attempted to look for pilots flying drones from the air, while the latter aimed to capture suspicious objects using a two-meter square net to ensure security.[226]

During an investigation of illegal dumping of waste materials, the Osaka Prefectural Police Department significantly reduced its labor force by using drones to determine locations of illegal dumping in mountainous areas.[227]

(3) Automated surveillance and detection system

To prevent terrorism and crimes in advance, a system is being developed to constantly monitor images from surveillance cameras using a facial recognition system and to notify security guards via smartphone when persons on a blacklist are detected.[228]

In Japan, technology is being developed to detect abnormalities by having AI machine learn the static states of systems and monitor and analyze them in real time based on the data of operating states of PCs and servers (e.g., program booting, file access, communication) as a cyber security measure.[229] Further, a system for detecting posted content and comments that may evolve into crimes based on open information posted on social media and bulletin boards and for notifying the surveillants is provided to governmental agencies.[230]

(4) Predictive policing

Predictive policing refers to efforts to predict crimes in advance by predicting the indications of crimes based on big data and information from various sensors and reinforcing security from actual sites. There are advanced cases of predictive policing using AI in the US, UK, Republic of Korea, and so forth.[231]

---

[225] "UK police introduces 'crime risk evaluation AI,' which automatically determines 'whether to detain or not' reducing false accusation!?," 2017.6.5. Same as above <https://roboteer-tokyo.com/archives/8986>. (in Japanese).

[226] "Ise-Shima Summit 2016: Protect with the latest equipment, drones catching drones," *Mainichi Shimbun* (Central region version), 2016.5.23, p.7. (in Japanese).

[227] "Drones now widely used for crime investigation and disaster rescue," 2016.9.10. Sankei News Website <http://www.sankei.com/west/news/160910/wst1609100020-n1.html>. (in Japanese).

[228] Isao Horikoshi, "Hopes for 5G from industry, even for prevention of crimes and unmanned driving," 2016.11.25. ITPro Website <http://itpro.nikkeibp.co.jp/atcl/column/16/111400259/111400004/?rt=nocnt>. (in Japanese).

[229] For example, "Cyber and physical: NEC's unique security technology makes society more secure and safer," 2017.3.10. NEC wisdom Website <https://wisdom.nec.com/ja/events/2017031001/02.html>. (in Japanese).

[230] UBIC, "UBIC discovers 'indications of crimes' on the internet, starts providing 'Lit i View SNS MONITORING' to ministries," 2016.3.1. Fronteo Website <http://www.fronteo.com/corporate/news/uploadfile/docs/20160301.pdf >. (in Japanese).

[231] Joel Gunter, "Chicago goes high-tech in search of answers to gun crime surge," *BBC News*, 2017.6.19. <http://www.bbc.com/news/world-us-canada-40293666>; Hachiyama, *op.cit.* (223), p.8; "Connecting with the police databases, Korea introduces "AI-equipped monitoring cameras in 2018, 2017.6.5. Roboteer Website <https://roboteer-tokyo.com/archives/8979> (in Japanese).; "UK police introduces 'crime risk evaluation AI,' which automatically determines

In Japan, the Kyoto Prefectural Police Department introduced the "Predictive Crime Defense System" (hereinafter "System") for processing the past statistical materials accumulated using a prediction algorithm based on multiple theories of criminology and predicting the time zones and locations where thefts and sex crimes may occur using computers in October 2016.[232] However, the System did not adopt machine learning; instead, humans created prediction logics to avoid turning analysis criteria into a "blackbox."[233] The prediction results are shared among devices used at *Koban* (police station) and police officers on duty through a network extended even to the *Koban* (police station) level within the precinct, which has contributed to streamlining police patrols.[234] According to the person in charge of the System in the Kyoto Prefectural Police Department, the System has contributed to dozens of arrests within a year of its introduction.[235]

The System plays the function of allowing police officers with little experience or officers not familiar with the area to perform police patrols smoothly. The System is also used for cooperation with crime-prevention volunteers in the area by releasing police patrol routes with detailed information abstracted, such as concrete crime occurrence locations, based on the analysis results.[236]

3. Issues surrounding the informatization of security: Availability and credibility of data

Many crime prediction and detection technologies bear the issue of privacy and are strongly influenced by the volume and quality of data. In the US, where many systems have been implemented, it is noted that half of rapes, robberies, and heinous assaults are not reported and thus not registered in the databases, posing questions regarding the credibility of such databases.[237] Because the private companies that developed the systems do not make analysis mechanisms available to the public (since they are company secrets), the credibility of the analysis mechanisms has also been questioned.[238] In Japan, where the absolute number of recognized criminal offenses is low in general, whether it is possible to improve the accuracy of the prediction results and expand the types of crimes that can be analyzed is a technological issue that should be discussed further.[239]

In the Kyoto Prefectural Police Department, infrastructures, including accumulated data on crime statistics and the network extended to the *Koban* (police station) level, were prepared in advance. Whether other prefectural police departments can establish such infrastructure on their own when the budget is limited and when there are various restrictions on the use of reasonably priced private-sector cloud services remains

---

'whether to detain or not' reducing false accusation!?," 2017.6.5. Same as above <https://roboteer-tokyo.com/archives/8986>. (in Japanese).

232 "Kyoto Prefectural Police Department: Introduces a crime prediction system in October first attempt in Japan," *Mainichi Shimbun* (Osaka version), evening paper, p.9. (in Japanese).

233 Yohei Ichijima, "On-the-spot arrest with big data, Kyoto Prefectural Police Department's prediction system," *Nikkei big data*, No.40, 2017.6, p.19. (in Japanese).

234 Interview with the person in charge at the Investigative Planning Division, Investigation Department, Kyoto Prefectural Police Department (December 11, 2017).

235 Same as above.

236 Same as above.

237 Toshihiro Yamada, "Reasons why Kyoto Prefectural Police Department's 'crime prediction system' is useful," 2016.10.6. ITmedia Website <http://www.itmedia.co.jp/business/articles/1610/06/news018.html>. (in Japanese).

238 Same as above.

239 Interview with the person in charge at the Investigative Planning Division, Investigation Department, Kyoto Prefectural Police Department (December 11, 2017).

one of the challenges for the dissemination of similar systems at a national scale. When adopting machine learning, analysis criteria can turn into a blackbox. Therefore, the accountability of prediction results for external organizations and ways to convince police officers to accept them are other issues to be discussed.[240]

About the Introduction and Use of the "Predictive Crime Defense System" in the Kyoto Prefectural Police Department
(Summary of the interview)

Mr. Hiroaki Okamoto
Investigative Planning Division, Investigation Department, Kyoto Prefectural Police Department

1. Upon the introduction of the System

The Kyoto Prefectural Police Department actively deals with the application of new technologies to policing and is working to address cybercrimes in a forward-thinking fashion. In terms of crime prediction, the department visited the Santa Cruz Police Department and Los Angeles Police Department in the state of California, US, for inspection in 2015. Both of these departments have implemented a crime prediction system called "PredPol." As a result of the inspection, the Kyoto Prefectural Police Department realized that it was difficult to introduce the American system as it is because the number of recognized crimes in Japan is much smaller than that in the US and because there are differences in the urban structures and police organizations. Therefore, the Kyoto Prefectural Police Department decided to build a unique system for Japan.

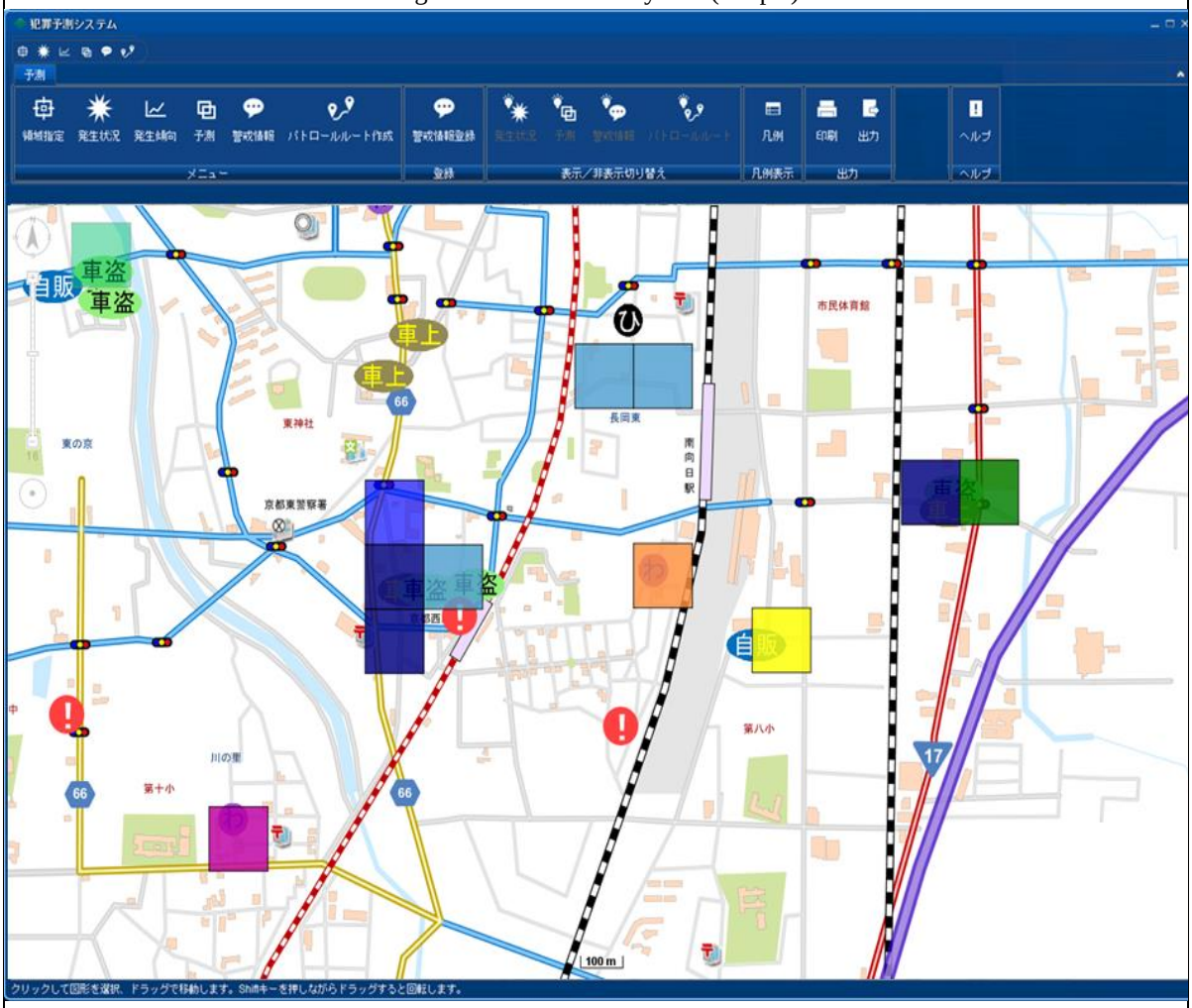
Data and infrastructure are necessary to build a system. Although police organizations in Japan cannot use external cloud services, in about 2004, the Kyoto Prefectural Police Department began accumulating crime data, established infrastructure for a unique geoinformation system (GIS), built a secure network that extends to the *Koban* (police station) level, and secured human resources familiar with IT. The network is isolated from that of fire departments and hospitals, and there is no plan to connect them as of today.

2. About the System

The system only accumulates data on the type of crime, date, time, and location. The types of crimes predicted are property crimes such as a burglar and sex crimes. Manual profiling is carried out for crimes with a small number of incident reports. The pattern of crime occurrence in the 150 square meter area is displayed. The department integrates (1) hot spot analysis theory and (2) theory of near repeat victimization into the system algorithms, and it predicts future cases based on the past crime occurrence data accumulated. The data are updated every few hours.

[240] Same as above.

Figure 1. Screen of the System (sample)



(Note) Colors indicate the types of crimes, and the density of colors indicate the degree of risk.
(Source) Investigative Planning Division, Investigation Department, Kyoto Prefectural Police Department

3. About the use of the System

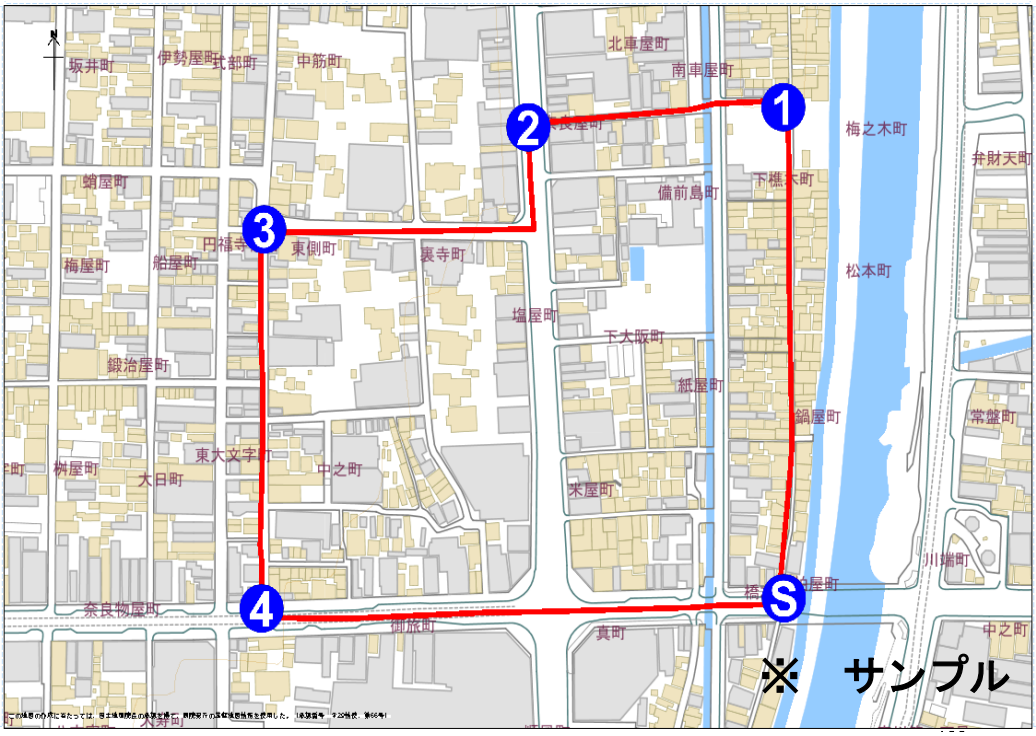
Police officers can access the System from their PCs at the headquarters and *Koban* (police station) through the secure network. The System is used when each police officer determines where to patrol or where to monitor, which contributes to efficient patrols. It also plays a supporting role so that even novice police officers who do not have the experience or intuition of experienced police officers or police officers who are not yet familiar with an area because they have just been assigned there can perform patrols smoothly. It has been a year since the introduction of the System, and there have been dozens of arrests through its use.

To “visualize” the achievements of the crime prediction system, the department shares use cases by honoring the police officers who have used the data successfully, and it has established a mechanism for motivating users.

Under the idea of community policing (cooperation between the police and the local community), the community safety division discloses the patrol routes with detailed information abstracted, such as

concrete crime occurrence locations, so that the System can be utilized in activities jointly carried out with local crime prevention volunteers.

Figure 2. Patrol route for the community (sample)



(Source) Investigative Planning Division, Investigation Department, Kyoto Prefectural Police Department

4. Future challenges

The System does not utilize deep learning. This is because it would be difficult for actual police officers to be convinced of the mechanism as well as logic of judgements, and to follow prediction results. It is necessary to evaluate the accuracy and credibility of the System itself in order to determine whether the System is being used. It is also necessary to develop evaluation indexes for determining its effect in deterring crime in the future.

The interview was conducted on December 11, 2017.

Takashi Seto, Asia Pacific Initiative

Arisa Ema, The University of Tokyo

Column 1: AI applications for Defense and National Security Overseas

1. Backgrounds on Applications of AI and robotics for defense and national security purposes

The use of unmanned weapon systems has increased in the military and national security spheres since the 2000s.[241] For example, according to a survey conducted by the Congressional Research Service (CRS)

[241] For example, see the following for the use of unmanned vehicles during the US's anti-terrorism operations in the Middle East and North Africa. Jessica Purkiss and Jack Serle, "Obama's Covert Drone War in Numbers: Ten Times More Strikes than Bush,"

in 2012, the share of drones among all the aircrafts owned by the US military was about 5% in 2005, but this figure drastically increased to about 40% in 2012.[242]

R&D investments in AI algorithm among the U.S. technology companies have continuously increased to an estimated $20-$30 billion in 2016, and will grow to as high as 126 billion by 2025.[243] The sophistication and proliferation of dual-use sensors embedded into military platforms allows military planners access to big data from battlefield.[244] In line with these trends, unique characteristics of AI such as dual-use and omni-use technologies, leading to a growing interest in AI applications for defense and national security, namely intelligence, surveillance, reconnaissance, logistics, cyberspace operations, command and control, as well as autonomous[245] weapon systems.[246] According to some analysts, competing AI R&D in relation to its use are now starting to be closely linked with military competition among nations.[247]

There are reasons why various countries have been aggressive in the application of AI and robotics for defense and national security purposes. The first reason is that machines can replace humans in performing 3D duties.[248] In general, unmanned weapon systems (and even autonomous weapon systems) have technological characteristics, such as the sustainability of functions independent from the physiological limitations of humans, low risk for operators, ease of downsizing, and relatively low development and operation costs compared with manned systems.[249] These characteristics contribute to the streamlining of operations and reduction of operation costs through a reduction in labor costs, among others.[250]

Secondly, political and social factors surrounding advanced nations, primarily European countries and the US, are sparking debate with respect to turning existing weapon systems into unmanned, labor-saving, and autonomous systems. Examples of such factors include the shortage of military personnel due to declining birthrates, aging population, and the popularization of higher education; prolonged and intensified anti-terrorism operations; the increased risks of operations associated with Russia and China's Anti-

2017.1.17. The Bureau of Investigate Journalism Website <https://www.thebureauinvestigates.com/stories/2017-01-17/obamas-covert-drone-war-in-numbers-ten-times-more-strikes-than-bush>.

[242] Jeremiah Gertler, "U.S. Unmanned Aerial Systems," *CRS Report for Congress*, R42136, 2012.1.3, p.9. <http://www.dtic.mil/dtic/tr/fulltext/u2/a566235.pdf>.

[243] Danie S. Hoadley and Nathan J. Lucas, "Artificial Intelligence and National Security," *CRS Report for Congress*, R45178, 2018 4.26,p.2

[244] Linton Wells II, "National Security Implications of the Fourth Industrial Revolution," 2016. 8.29, Centre of Excellence for National Security (CENS), Distinguished Visitor Program (DVP) Lecture, STAR-TIDES Website, pp.7-15 <http://star-tides.net/sites/default/files/documents/files/Natnl%20Sec%20Impl%20of%204th%20Ind%20Rev%20for%20Singapore%20generic%208-29-16b%20final.pdf>.

[245] See the following for the difference between "unmanned" and "autonomous" and arguments over the definition of the latter. Reito Kawaguchi, "A Consideration of the Progress of Future military Science and Technology and Military Management: About Regulations on Lethal Autonomous Weapon Systems (LAWS), *NIDS Journal of Defense and Security*, Vol.19 No.1, 2016.12, p.216. <http://www.nids.mod.go.jp/publication/kiyo/pdf/bulletin_j19_1_8.pdf> (in Japanese); See Hoadley and Lucas, *op.cit.*(243) pp. 1-4.

[246] Hoadley and Lucas, *op.cit.*(243) pp. 8-13, and Executive Summary.

[247] Tom Simonite, "For Superpowers, Artificial Intelligence Fuels New Global Arms Race," *WIRED*, 2017.9.8. <https://www.wired.com/story/for-superpowers-artificial-intelligence-fuels-new-global-arms-race/>.

[248] 3D means dull, dirty, and dangerous. Typical duties include long-term monitoring, activities in areas contaminated with chemical agents, biological agents, or radiation, and search and removal of landmines and sea mines. Ken Jimbo, "Unmanned system, robotics and national security," *Kokusai Mondai (International Affairs)*, No.658, 2017.1.2, p.18 (in Japaese).

[249] Ministry of Defense, "R&D vision for future unmanned equipment: Focusing on unmanned aircrafts," 2016.8.31, p.3. <http://www.mod.go.jp/atla/soubiseisaku/plan/vision/future_vision.pdf> (in Japanese).

[250] Kawaguchi, op.cit.(245) p.217.

Access/Area Denial (A2/AD)[251] capabilities[252]; the national opinion in advanced democracies especially after the end of the Cold War, leaning toward the direction that sacrificing own citizens in wars should be avoided, which is a trend commonly known as a post-heroic society[253], the escalating prices of defense equipment and procurement,[254] as well as budgetary constraints[255] of the national defense ministries of various countries.

In addition, some powers expect to maintain military superiority by AI applications and autonomous weapons. The points of what experts argue are following; (1) autonomous weapon systems is likely to gain greater battlefield advantages than manned ones, because they can be made smaller, lighter, faster, more maneuverable, and resilient to electro-magnetic warfare being unbounded by physiological limits of humans. (2) enhanced C4ISR (Command and Control Communication Computer Surveillance and Reconnaissance) and common operating picture (COP) through application of AI greatly streamlines multi-domain operations across land, air, sea and outer-space as well as cyber-space, which maintains tactical superiority over and imposes significant costs on adversaries across multi-domain kinetic operations[256].

2. Introduction of cases in various countries

(1) United States of America

Under the administration of Barack Obama, the U.S. Defense Department (DoD) announced the "Third Offset Strategy[257] (TOS)" as one of its strategic initiatives in November 2014.[258] It is a strategy to keep its technological edge and deterrence over adversarial peers, through pursuing a triple-pronged approach of (1) technological innovation, (2) reinventing concept of operations (CONOPs) of U.S. Forces, and (3) organizational reform of the U.S. Defense Department and U.S. forces.[259]

---

[251] A2/AD generally refers to a country's ability to increase the risk of power-projection capabilities consisting of ships, aircrafts, bases, and command and control systems and to be able to stop interventions with regional conflicts (environment) using ballistic missile and cruise missile attacks, submarines, and cyber and electronic attacks. See the following for China and Russia's A2/AD. Stephen Biddle and Ivan Oelrich, "Future Warfare in the Western Pacific: Chinese Antiaccess/Area Denial, U.S. AirSea Battle, and Command of the Commons in East Asia," *International Security*, Vol.41 No.1, Summer 2016, pp.7-48. <https://www.mitpressjournals.org/doi/pdf/10.1162/ISEC_a_00249>; Stephan Frühling and Guillaume Lasconjarias, "NATO, A2/AD and the Kaliningrad Challenge," *Survival*, Vol.58 No.2, 2016.3, pp.95-116.

[252] See the following for a background on A2/AD ability and environments in which military has ask for unmanned weapons and AI. Patrick M. Cronin et al., *Dynamic Balance: An Alliance Requirements Roadmap for the Asia-Pacific Region*, Washington: Center for a New American Security, 2016.5, pp.11-12. <https://s3.amazonaws.com/files.cnas.org/documents/CNASReport-AllianceRoadmap-Final.pdf?mtime=20161010171119>; Shawn Brimley et al., *While We Can: Arresting the Erosion of America's Military Edge*, idem, 2015.12, pp.5-9. <https://www.files.ethz.ch/isn/195455/While%20We%20Can-151207.pdf>.

[253] Marouf Hasian Jr., *Drone Warfare and Lawfare in a Post-Heroic Age*, Tuscaloosa: University of Alabama Press, 2016, pp.19-47.

[254] Sam Jones, "AI and Robots Line up for Battlefield Service," *Financial Times*, 2016.11.6. <https://www.ft.com/content/02d4d586-78e9-11e6-97ae-647294649b28>.

[255] Satoru Mori, "Chapter 5: 'Offset Strategy' and 'national defense innovation initiative' of US," Japan Institute of International Affairs (ed.), "*Various domestic factors affecting US's diplomatic policies*," Japan Institute of International Affairs, 2016.3, p.63. <http://www2.jiia.or.jp/pdf/research/H27_US/05-mori.pdf> (in Japanese).

[256] Paul Scharre, *Army of None: Autonomous Weapons and the Future of War* Newyork: W.W Norton & Company, 2018 pp. 14-16, Mori, op.cit.(255), pp.61-62; Satoru Mori, "Technology and national security: Vision for adoption of autonomy in US's national defense innovation," *Kokusai Mondai* (*International Affairs*), No.658, 2017.1.2, pp.27-31 (in Japanese).

[257] "Offset Strategy" is a national defense term in the US and means a "strategy to secure more than enough military capabilities to offset military advantage of enemies by combining weapons, systems, and operation concepts in a new way to create deterrence." Mori, op.cit.(255), p.53 (in Japanese).

[258] "Regan National Defense Forum Keynote: As Delivered by Secretary of Defense Chuck Hagel," 2014.11.15. U.S. Department of Defense Website <https://www.defense.gov/News/Speeches/Speech-View/Article/606635/>; Secretary of Defense, *Memorandum: The Defense Innovation Initiative*, 2014.11.15. <http://archive.defense.gov/pubs/OSD013411-14.pdf>.

[259] Mori, "Technology and national security," op.cit.(255), pp.55-56.

DoD and the U.S. Forces have been struggling to keep military superiority over and deterrence through innovation and maintain their technological edge while cutting-edge technologies are quickly proliferating throughout the world. Various measures of the strategy have been passed down to the current administration of Donald Trump.[260]

In 2015, the Defense Science Board (DSB), an organization in charge of the promotion of TOS in the U.S. Defense Department, discussed in detail the concept of "autonomy," which means "autonomy" through a group of relevant technologies, such as AI, robotics, and big data, and the possibilities of their use for national security purposes[261]. The DSB report includes recommendations on specific applications of AI in the DoD, including swift information collection and tailored analysis, timely logistics based on monitoring of the status and condition of troops, and human-machine teaming through the integration of AI into various layers of military platforms, C4ISR networks and operational process.[262] The report also estimates that AI can be utilized in the long run, for (1) predicting any destabilization in the political and socio-economic landscape, (2) creating autonomous swarms,[263] (3) detecting large-scale intrusions on the IoT systems, (4) building cyber-resilient weapons (equipped with the function to automatically fix the system through machine learning), and (5) performing swift planning of air operations.[264] Following this, R&D as well as AI experiments have been conducted within the Defense Advanced Research Projects Agency (DARPA) and Intelligence Advanced Research Project Agency (IARPA), as well as among the 4 services.[265]. In addition, the Office of the Assistant Secretary of Defense for Research and Engineering (ASD/RE) maintain loose oversight of these initiatives, and is in the process of drafting a DoD AI strategy, which said to be published in summer 2018.[266] As of May 15 2018, some notable initiatives exist under Trump Administration, accelerating the integration of AI into the DoD and U.S. Forces for planning and war-fighting.

---

[260] Both National Security Strategy (NSS) and National Defense Strategy (NDS) formulated by the Trump administration also say that research and development of advanced technology is important to secure the superiority of US, and AI is addressed as one of the examples of advanced technology. National Security Strategy of the United States of America, 2017.12, pp.20-21. <https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf>; Summary of the National Defense Strategy Sharpening the American: Military's Competitive Edge, 2018.1, pp.3, 7. <https://www.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>. and also see Tom Simonite, "Defense Secretary James Mattis Envies Silicon Valley's AI Ascent," *WIRED*, 2017.8.11. <https://www.wired.com/story/james-mattis-artificial-intelligence-diux/>.

[261] The results of the deliberation were published as a report in the summer of 2016. See the following for the implications of autonomy. Defense Science Board, *Summer Study on Autonomy*, 2016.6. <https://fas.org/irp/agency/dod/dsb/autonomy-ss.pdf>.

[262] *Ibid*, pp.45-76..

[263] A swarm means that a "swarm" of many drones share data collected by each drone in the swarm to perform attacks and defense by synchronizing and coordinating the drones in the swarm as an autonomous weapon. By interconnecting the autonomous drones, the swarm will gain invulnerability (ability to maintain functions) to electronic attacks, such as jamming. By effectively using drones that can be mass produced, emerging countries and developing countries that tend to lose numerical (quantitative) advantage in battlefields against the militaries of advanced countries, due to the costs of weapon manufacturing and people development, will generally be able to offset their numerical disadvantage to enemies. Mori, "Technology and national security," *op.cit.* (255), p.30; Paul Scharre, *Robotics on the Battlefield Part II: The Coming Swarm*, Washington: Center for a New American Security, 2014.10. <https://s3.amazonaws.com/files.cnas.org/documents/CNAS_TheComingSwarm_Scharre.pdf?mtime=2016090608209>.

[264] Defense Science Board, *op.cit.* (261), pp.76-97..

[265] This includes the development of AI-equipped autonomous unmanned underwater vehicles (UUVs) and the structuring of strike groups consisting of autonomous and manned vehicles. See the following for details. Shigeo Kikuchi & Hiromu Arakaki, "Chapter 7: US: Addressing the return of competition among major nations," National Institute for Defense Studies (ed.), *The East Asian Strategic Review 2017*, 2017, pp.197-202. <http://www.nids.mod.go.jp/publication/east-asian/pdf/eastasian2017/j07.pdf> (in Japanese).

[266] Hoadley and Lucas, *op.cit.* (243) pp. 8-13.

Firstly, DoD launched initiatives named Algorithmic Warfare Cross-Functional Team, known as "Project Maven" in April 2017.[267] The purpose of this project is to accelerate, improve, and put to wider use the military's utilization of machine learning, especially for the time being, on intelligence collection and analysis.[268] As part of this project, machine learning has been utilized for the analysis of massive flows of images and videos from UAVs operating at Iraq and Syria, leading the hunt for insurgents of ISIL.[269]

Secondly, the U.S. Army Training and Doctrine Command (TRADOC) requested the reinforcement of functions to gather and analyze information using AI in their report of the Multi-Domain Battle (MDB) concept, which is a potential future CONOPs for the army, published in December 2017.[270]

Thirdly, under the incumbent Deputy Secretary of Defense Patrick Shanahan, the DoD is accelerating initiatives for establishing infrastructures to boost the application of AI. They include military cloud data storage covering multiple departments of the DoD and its services from decision makers to battlefield operators, commonly known as Joint Enterprise Defense Infrastructure contract (JEDI)[271], as well as the AI Center of Excellence, which pull together multiple existing military programs regarding AI application and work.[272]

(2) Israel and Europe

Israel has been promoting the application of AI and robotics in 3D tasks of anti-terrorism operations and border security in particular. In July 2016, Israel began fielding the AI-equipped, fully autonomous military vehicle called "Border Protector," which now fulfils the role of monitoring the border area in the Gaza Strip in Palestinian territories. The vehicle is an unmanned ground vehicle (UGV) for surveillance and reconnaissance. At this point, it does not have the ability to kill or injure, but the Israeli military is planning to have it equipped with machine guns to build a combat troop teaming the autonomous weapon system and humans soldiers and have it play a part in border protection.[273] Analysts maintain that the revolving-door systems between military, government and businesses is a feature of the Israeli AI start-up ecosystem[274], which leads to rapid application of AI to national security.

In Europe, NATO member states are also try to keep pace with the United States in the field of AI. In March 2018, French President Emmanuel Macron announced a strategy for innovation and utilization of AI

---

[267] Memorandum of Deputy Secretary of Defense, DoD, "Establishment of an Algorithmic Warfare Cross-Functional Team (Project Maven)," < https://www.govexec.com/media/gbc/docs/pdfs_edit/establishment_of_the_awcft_project_maven.pdf> 2017.4.26.

[268] Sydney J. Freedberg Jr., "'Algorithmic Warfare:' DSD Work Unleashes AI on Intel Data," 2017.4.28. Breaking Defense Website <https://breakingdefense.com/2017/04/dsd-work-unleashes-ai-on-intel-data-algorithmic-warfare/>.

[269] Hoadley and Lucas, *op.cit.* (243) p.9, and Executive Summary.

[270] United States Army Training and Doctrine Command, *Multi-Domain Battle: Evolution of Combined Arms for the 21st Century: 2025-2040 (Version 1.0)*, 2017.12, p.54. <http://www.tradoc.army.mil/multidomainbattle/docs/MDB_Evolutionfor21st.pdf>.

[271] Sydney J. Freedberg Jr. "War Cloud: JEDI To Deploy Backpack Servers To Front Line," Breaking Defense Website, 2018. 4. 23 < https://breakingdefense.com/2018/04/war-cloud-jedi-to-deploy-backpack-servers-to-front-line/>

[272] Matt Stroud R. and Jeffrey Smith, "Trump Administration Accelerates Military Study of Artificial Intelligence" The Center for Public Integrity Website, 2018.4.26 < https://www.publicintegrity.org/2018/04/26/21707/trump-administration-accelerates-military-study-artificial-intelligence>

[273] "Endless war: Robot troop starts operation, autonomous military vehicles on actual battlefield, the world's first attempt by Israel," *Mainichi Shimbun*, 2016.8.24, p.1 (in Japanese).

[274] Shepherd Laughlin, "Spotlight: Israel's Startup Ecosystem," J. Walter Thompson Intelligence Website, 2017.6.2 < https://www.jwtintelligence.com/2017/06/spotlight-israels-startup-ecosystem/>

in France and Europe, proposing the establishment of the DRAPA-like organization at the EU-level.[275] NATO member states will conduct more than 20 AI-related experiments in next major exercise "Trident Juncture", organized by the Allied Command Transformation in October and November 2018, which include an effort to autonomously detect, diagnose, and deliver care to wounded soldiers[276].

(3) China & Russia

China and Russia are also trying to invest in research and development towards the aggressive use of AI and robotics for military and national security purposes as national strategies, though China and Russia are, for the time being, technologically inferior to the U.S.[277] China's "Next Generation AI Development Plan" emphasizes that "China will finally seize the initiative" and reach "world leading levels" of AI investment by 2030, spending over $150 billion on R&D through government funding.[278] Russia, as well, has been struggling to keep pace with the U.S. and China. The Russian Military Industrial Committee, for example, has set a goal for 30% of military equipment to be replaced by robotics by 2025, and the Russian government has established a DARPA-like organization as well as initiated an annual conference on "Robotization of the Russian Federation".[279]

Their approach of technological application have been developing with those of the U.S. in mind. Simply put, they are also trying to upgrade intelligence collection and analysis, cyber-defense readiness, identification and tracking of targets as well as precision-strike capabilities, and command and control for their armed forces, even though their ethics and limits on military use of AI may be different from those of the U.S.[280]

3. Future challenges of AI applications to defense and national security

(1) Debates and issues pertaining to regulations over lethal autonomous weapon systems (LAWS)

Scientists and NGOs of various countries have insisted on regulations over the development of LAWS, which can autonomously target and kill/injure targets without the supervision of human operators, commonly called lethal autonomous weapon systems with "humans out of the loop".[281] Regulations over LAWS are

---

[275] Government of Republic of France, Press Release, "Artificial Intelligence: 'Making France a leader'," 2018.3.18. < https://www.gouvernement.fr/en/artificial-intelligence-making-france-a-leader>

[276] Patrick Tucker, "How NATO's Transformation Chief Is Pushing the Alliance to Keep Up in AI," Defense One Website, 2018.5.18, < https://www.defenseone.com/technology/2018/05/how-natos-transformation-chief-pushing-alliance-keep-ai/148301/>

[277] Simonite, *op.cit.*(260) Stephan De Spiegeleire et al., *Artificial Intelligence and the Future of Defense: Strategic Implications for Small- and Medium-Sized Force Providers*, Hague: The Hague Centre for Strategic Studies, 2017, pp.77-84. <https://hcss.nl/sites/default/files/files/reports/Artificial%20Intelligence%20and%20the%20Future%20of%20Defense.pdf>.

[278] Hoadley and Lucas, op.cit. (243), pp.17-18, On overview of China's AI development strategy and PLA military thinking on AI and warfare, see following Elsa B. Kania, *Battlefield Singularity: Artificial Intelligence, Military Revolutions, and China's Future Military Power*, Washington: Center for New American Security, 2017. 11.28, pp. 8-19. < https://s3.amazonaws.com/files.cnas.org/documents/Battlefield-Singularity-November-2017.pdf?mtime=20171129235804 >

[279] Hoadley and Lucas, Hoadley and Lucas, op.cit. (243) pp. 21-22, see also following Samuel Bendett, "Robots Rising: Behind the Rapid Development of Russian Unmanned Military Systems," *Strategy Bridge*, 2017. 12. 12. <https://www.realcleardefense.com/articles/2017/12/12/red_robots_risin_112770.html>

[280] Hoadley and Lucas, Hoadley and Lucas, op.cit. (243) pp. 21-22.

[281] For example, see、Human Rights Watch and Harvard Laws School's International Human Rights Clinic, "Losing Humanity: The Case against Killer Robots," 2012.11. <https://www.hrw.org/sites/default/files/reports/Losing%20Humanity%20Executive%20Summary.pdf>; Samuel Gibbs, "Elon Musk leads 116 experts calling for outright ban of killer robots," *Guardian*, 2017.8.20.

now being discussed mainly within the framework of the Convention on Certain Conventional Weapons (CCW)[282] from the perspectives of the international humanitarian law and international arms control regimes.[283] On the other hand, debates and articulation on regulatory schemes of weapons that do not exist at this point are difficult. Some experts are concerned that early and strict regulations may interfere with R&D efforts in the private sector, considering the dual use nature of AI, and may have negative impacts on the development and application of other useful military AI technologies.[284]

(2) Influence on international relations and national security policies

Experts of international relations and national security policies in the U.S. and Europe emphasize that AI will influence wars and international relations as much as nuclear weapons did in the past.[285]

Experts point out that the features and consequences of AI applications, namely the rapid proliferation of underlying technologies, the growing accuracy and speed of intelligence, and subsequent rapid decision-making and operational tempo, may lead to reduce "strategic stability[286]" among great powers in three ways: (1) accelerating an arms race, (2) increasing the risk of accidental escalation during crisis and conflict, and (3) degrading the stability of nuclear deterrence among nuclear states through their fear of their own second-strike capabilities being devastated by the adversaries' rapid and accurate first-strike augmented by AI, which would incentivize them to rush into their nuclear first-use.[287]

Furthermore, some are concerned that an overwhelming disparity regarding their tactical and operational level of C4ISR between allies, with one that has integrated AI into their platforms compared to the other that has not, may negatively impact joint operations under contingency.[288]

(3) Challenges on organizational culture and acquisition process, and data accessibility / security of defense and national security organizations

---

<https://www.theguardian.com/technology/2017/aug/20/elon-musk-killer-robots-experts-outright-ban-lethal-autonomous-weapons-war>.

[282] Convention on Certain Conventional Weapons (Ordinance No. 12 of 1983) (enacted on December January 1083 and came into effect on the same day in Japan).

[283] See Kawaguchi, *op.cit.*(245), pp.221-223, for the trend of past discussions. CCW's LAWS experts meeting was held from November 13 to 18 in 2017. The delegates of the Japanese government stated, "it is difficult to gain a consensus on the clear definition of LAWS at this moment, but it is important to have realistic discussions on the current situations of technologies that have autonomous functions and their future prospect. Japan would like to participate in discussions actively, for example, by providing knowledge, among others, as a country that owns advanced technology in terms of robotics and AI in relation to LAWS. "About the meeting of the CCW's Group of Governmental Experts on LAWS," 2017.11.20. Ministry of Foreign Affairs of Japan Website <http://www.mofa.go.jp/mofaj/press/release/press4_005290.html> (in Japanese).

[284] Mary L. Cummings, *Artificial Intelligence and the Future of Warfare*, London: Chatham House, 2017.1, pp.1-12. <https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2017-01-26-artificial-intelligence-future-warfare-cummings-final.pdf>, Heigo Sato, "Warfare of Lethal Autonomous Weapon Systems," Takashi Kawakami eds, *What is future of Warfare*, Minerva Publications, 2017.1.20 p. 68 (in Japanese).

[285] For example, see the following. Greg Allen and Taniel Chan, *Artificial Intelligence and National Security*, Cambridge: Harvard Kennedy School Belfer Center for Science and International Affairs, 2017.7, pp.9-10. <https://www.belfercenter.org/sites/default/files/files/publication/AI%20NatSec%20-%20final.pdf>

[286] Strategic stability is a technical term in the field of nuclear deterrence, which can be divided into the issues of incentives on (1) nuclear first-use, (2) conflict escalation, and (3) arms-control(race). See following Edward Geist and Andrew J. Lohn, *How Might Artificial Intelligence Affect the Risk of Nuclear War*? RAND Cooperation 2018.4.23 p.8. https://www.rand.org/pubs/perspectives/PE296.html > and Jürgen Altmann and Frank Sauer, "Autonomous Weapon Systems and Strategic Stability," *Survival*, Vol.59 No.5, 2017.10/11, pp.121-122.

[287] Geist and Lohn, Ibid. pp. 6-20. On AI arms race, see following Altmann and Sauer, Ibid.pp.120-135.

[288] Mori, "Technology and national security," *op.cit.* (255), pp.32-33.

The organizational culture of military and national defense authorities can be factors that hinder the use of AI and autonomy in the military and national security spheres. Militaries have a strong tendency to value hierarchy and top-down command and control. If decisions are made autonomously or automatically (decentralization) and if organizations become flat with the introduction of AI[289], this may cause some friction between technology and the existing organizational culture.[290] In addition, some military organizations traditionally have a strong tendency to emphasize manpower and other human elements. In U.S. military forces where unmanned weapon systems have been implemented at the highest standard, many people revolted against implementing unmanned labor-saving systems during the process of procuring and operating unmanned attack planes such as the X-47.[291] Such an organizational culture can be a factor hindering the dissemination of AI and autonomous weapons in the military and national security spheres.

It has also been noted that there may be conflicts between the organizational cultures of national security organizations and private sector including tech-giants, start-ups and universities.[292] Exposure of Google's contribution to the DoD's Project Maven in April 2018, for example, has sparked fierce protest and debate among their engineers on their involvement in defense programs.[293] The other pressing issue is the reform of the acquisition process for AI because there has been huge gap between the lingering process of defense acquisition (in the case of US, 91 months for defining requirement, on average) and private software vendors production cycle (around 6 to 9 months)[294].

Finally, accessibility and security of data sources for military AI pose challenges. Military information and intelligence is often classified, protected and stove-piped among services, having themselves difficult to be proceeded for machine learning[295]. In addition, complex and constantly changing environment of battlefield could easily degrade credibility of data pool, and allows adversaries' data poisoning, leading to flaw and vulnerabilities of learning process[296].

Takashi Seto, Asia Pacific Initiative

---

[289] See following discussion of Peter W. Singer, *Wired for War: The Robotics Revolution and Conflicts in the 21st Century*, Penguin Books 2009.

[290] Lena Andrews and Julia Macdonald, "Five Costs of Military Innovation," 2016.2.18. War on the Rocks Website <https://warontherocks.com/2016/02/five-costs-of-military-innovation/>; Cummings, *op.cit.*(284), p.9; Denise E. Zheng and William A. Carter, *Leveraging the Internet of Things for a More Efficient and Effective Military*, Washington: Center for Strategic and International Studies, 2015.9, p.23. <https://csis-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/publication/150915_Zheng_LeveragingInternet_WEB.pdf>

[291] Cummings, *ibid.* It is said that there is a clear hierarchy between pilots of manned aircrafts and operators of unmanned aircrafts in the air force, where duties of pilots are considered particularly important.
Koji Inoue, *Century of drones: From aerial photography, parcel delivery, to armed unmanned aircrafts*, Chuokoron Shinsha, 2015, p.176 (in Japanese).

[292] Cummings, *op.cit.* (284), pp.8-12.

[293] Sean Holliste, "Project Maven: Nearly a Dozen Google Employees Have Reportedly Quit in Protest," CNET Website < com/news/google-project-maven-drone-protect-resign/> 2018.5.14.

[294] Hoadley and Lucas, *op.cit.* (243) pp. 13-17.

[295] Hoadley and Lucas, *op.cit.* (243). pp.7-8.

[296] Greg Allen and Taniel Chan, *op.cit.* (285), p.25. Hoadley and Lucas, op.cit. (243), pp. 31-33.

Column 2: Japanese Chess (*Shōgi*)

1. Significance of implementing software in the world of *shōgi*

In the Shōgi DENOU Tournament,[297] professional *shōgi* players lost to *shōgi* software (hereinafter "software"). The news drew considerable attention within Japanese society.[298] People began to realize that various professions would be replaced by software due to advancements in AI technology, and some showed concern on *shogi*-related websites that the professional status of *shōgi* players is at risk, as they were overwhelmed by software during the games.[299]

However, we feel that the concern regarding "AI taking away *shōgi* players' jobs" is based on mere speculation without any good justification. Professional *shōgi* players have a profession not because they play *shōgi* but because *shōgi* fans, newspapers, and TV stations pay to watch the games, see the game records, and hear the related commentary. Certainly, the Shōgi DENOU Tournament, where *shōgi* players and software played games, achieved a certain level of success as a form of entertainment.[300] However, the games in the World Computer Shōgi Championship, where software plays against software, and "floodgate,"[301] the site for computer *shōgi* games, are not necessarily attracting more fans than *shōgi* tournaments where professional *shōgi* players play against each other. The fee-charging *shōgi* game broadcasting app ("Japan *Shōgi* Association's Mobile Broadcasting") mainly broadcasts games between *shōgi* players, whereas not many fans pay for records of or commentaries on games played by computers, as shown by the fact that anyone can access floodgate for free. It is also difficult to implement elements other than "being good at *shōgi*", which are the foundations underlying the profession of *shōgi* players (e.g., being a good commentator or teacher, having personal magnetism, interacting with fans), into the software. Currently, *shōgi* software has not achieved anything when it comes to "replacing the profession of *shōgi* players," and it has no prospect for doing so.

In terms of the introduction of software in the world of *shōgi*, instead of software's potential for replacing human jobs, we need to look into how software and humans can collaborate with each other and how human actions change through collaboration with software, when software obtains abilities equal or superior to the level of people, as discussed later.

---

[297] The DENOU Tournament is a *shōgi* tournament sponsored by Dwango since 2012 where *shōgi* players and *shōgi* software play each other. "DENOU Tournament" Japan *Shōgi* Association Website <https://www.shogi.or.jp/match/denou/>. (in Japanese)

[298] "Professional *shōgi* players are defeated in a row, 3rd game of the second DENOU Tournament, 'Tsutsukana' goes on the offensive from the beginning, 'It was strong'," Asahi Shimbun, 2013.4.9, p.7 (in Japanese); "Last game of DENOU Tournament, software wins, Grand *shōgi* master Sato, 'moves I have never thought of'," Mainichi Shimbun, 2017.5.21, p.30. (in Japanese)

[299] "Records of internet flaming," 2016.9.11 A-class League Move No.1 (Blog of Mr. Hidenori Ito, developer of *shōgi* software) <http://aleag.cocolog-nifty.com/blog/2016/09/post-e24a.html> (in Japanese).

[300] During the second DENOU Tournament in 2013 and the third DENOU Tournament in 2014, it is said that the total number viewers of "Niconico Namahoso," a live streaming service provided by Dwango, exceeded 2 million. "Number of those who watched DENOU Tournament on Niconico Namahoso exceeds 2 million, hitting a record high of *shōgi*-related broadcasting programs," 2013.4.22. MyNavi News <https://news.mynavi.jp/article/20130422-a287/> (in Japanese); The total number of viewers of the third Shōgi DENOU Tournament reaches 2.13 million, exceeding that of previous year. 710,000 people watched the fifth game, hitting a record high," 2014.4.15. MyNavi News <https://news.mynavi.jp/article/20140415-a443/> (in Japanese).

[301] Computer *Shōgi*-Server (floodgate) <http://wdoor.c.u-tokyo.ac.jp/shogi/floodgate.html>. (in Japanese)

2. Shifts in the development of *shōgi* software

The development of *shōgi* software began in the 1970s. Up to the early 2000s, evaluation functions[302] were built manually based mainly on the knowledge of developers familiar with *shōgi* and advice from professional *shōgi* players. What was considered important was to understand how top-class human *shōgi* players choose a move in their head and to reproduce such thought processes in software using algorisms.[303]

In contrast, the method of Bonanza, software developed in 2005 by Mr. Kunihito Hoki (currently associate professor of the University of Electro-Communications, Graduate School of Informatics and Engineering, School of Informatics and Engineering), who was a physical chemist and was not very familiar with *shōgi* at the time, is based on a full width search, which evaluates all the moves from every aspect, and on records of games played by professional *shōgi* players. Major software using this method was subsequently developed. They aimed to make software change (learn) to choose the moves that are likely to be chosen by top-class *shōgi* players with a high probability, instead of converting *shōgi* moves into explicit sets of rules (algorithm). Therefore, there has been a setback in terms of the elucidation of human thought processes during *shōgi* games.[304] Since the speed and accuracy of learning improve as computers become faster, even developers themselves cannot easily understand how major software chooses the moves.

Thus, the *shōgi* software developed recently that ended up overwhelming *shōgi* players fully utilized the computing skills of computers, highly accurate reading abilities (search of aspects that can be anticipated), and *taikyokukan* (broad-based perspective) (evaluation functions), but thought processes leading to a move have gradually turned into a blackbox. We cannot make generalizations without careful consideration, but process where the internal principle of software is difficult to understand based on the intellectual abilities of people, including the developers themselves, as the capabilities of software are enhanced (or as the elaboration of internal mechanisms independent from the intellectual understanding of people results in the enhancement of software capabilities) may be commonly seen among the core technologies of the recent AI boom, including machine learning and deep learning.

3. Influence of *shōgi* software

Shōgi players finished the Shōgi DENOU Tournament, with 5 wins, 10 losses, and 1 draw. In response to these results and the game content,[305] *shōgi* software began to have various effects on professional *shōgi* players. The unusual moves used by software in the Shōgi DENOU Tournament began to be used during games between professional *shōgi* players. The effectiveness of such moves is now explored as the "new moves of software." Some of these new moves are mentioned in books regarding *jōseki* (recommended sequences of moves). Thus, the influence of software is apparent in some *jōseki* and tactics. This influence of software is an extension of choices through the "search of information." Software equipped with the "full width search" function, which can search all possible moves for every aspect, demonstrated that there are

[302] Functions that output values representing the advantage and disadvantage of aspects. These are the main elements that affect binary search, discussed later, and software's ability related to *shōgi*.

[303] Hiroyuki Iida, *Can computer win against grand shōgi master?*, Iwanami Shoten, 2002. (in Japanese)

[304] Computer *Shōgi* Association (ed.), *How to create computer shōgi that can win against humans*, Gijutsu-Hyohron Co., 2012. (in Japanese)

[305] Akinori Kubo, "How we should deal with computing intellect: Near future of humans and computers seen from Shōgi DENOU Tournament," 2014.3.29. SYNODOS Website <http://synodos.jp/science/7549>. (in Japanese)

possibilities for moves that were likely to be excluded in *taikyokukan*, which professional *shōgi* players have developed.

Now, professional *shōgi* players, mostly young ones, have begun to use software for research before the final phase of the Shōgi DENOU Tournament and even after the tournament. Here, they are not just exploring the possibilities of new moves and tactics but also trying to change their *taikyokukan* by referencing the positional judgments of software, thinking that *taikyokukan*, which has been considered sacred as the essence of *shōgi* players' ability, might just be "prejudice," which is based on conventional ideas and emotions such as fear and hope.[306] These trends are very suggestive of the way that software is beginning to assume an important role not just for the "search of information" but for the "evaluation of information," which only humans have been doing thus far. Shifts from tools for supporting the "search of information" to tools for also supporting the "evaluation of information" can be amplified to shifts from "internet-related" technology to technology now called "AI" in more general terms.

4. Future prospects

Yet, there are only a few professional *shōgi* players who have an entirely positive opinion about research using software (including consideration of the evaluation value). If the evaluation value of software is not bad, players can choose the moves that have been traditionally avoided because of the lower odds of winning and their fear of using them during actual games. In this sense, software has become a "lucky charm" (a phase used by a young *shōgi* player) that eases the players' anxiety when they choose moves that have traditionally been avoided, clearly expanding the possibilities of those *shōgi* players.

On the other hand, some players have expressed the negative opinion that if they rely too much on the evaluation value of software, they will tend not to think with their head and thus "lose their comprehension muscle."[307] As discussed earlier, the thought processes involved in the major software currently available have become too complex for people to understand. If they follow only the surface of the choices proposed by software, they may lose control of the progress of the game, which may lead to the deterioration of their thought processes and the use of ill-supported moves.

The changes in today's *shōgi* games as a result of software, as described above, were rapidly facilitated in various ways, because the success or failure of *shōgi* as a form of entertainment in allowing people to watch "games" is considered the most important element in the *shōgi* profession and there are relatively fewer customary or ethical constraints on them. However, we cannot easily view the introduction of software in the world of *shōgi* as an example of labor market changes as a result of AI, as discussed at the beginning. We can consider this a pioneering model case that is highly suggestive even for other domains, from the perspective of how collaboration with software equipped with highly intellectual abilities can change our thoughts and behaviors.

Akinori Kubo, Hitotsubashi University

[306] Shota Chida & Akinori Kubo, "Machine and human, going the third way," *E! Eureka Project*, Vol.8, 2016.4.20, pp.10-42. <http://eureka-project.jp/2016/04/20/e8/#>. (in Japanese)
[307] Shintaro Okawa, *Indomitable shōgi player*, Kodansha, 2016, pp.196-203. (in Japanese)

Part 3

AI and Employment Overseas, and in Development, Utilization and Management of Human Resources

Part 3: AI and Employment Overseas and in the Development, Utilization, and Management of Human Resources

[Overview]

Part 2 focused on AI users, mainly experts in several areas and domains in Japan, and provided an overview of the situation surrounding AI, robotics, employment, and labor, from legal, social, ethical, and technological perspectives. Experts in each domain use AI and robotics as one of the means to achieve their objectives; in other words, "using AI and robotics" is not their goal. Further, AI and robotics do not stand alone. They require infrastructure, such as communication networks and hardware. Also they function as one of the elements of a system consisting of existing environments, institutions, the economy, people's literacy, human values, and organizational culture.

Interactions between technology and society vary not only by field but also by country and region. Therefore, the first half of Part 3 reviews what kind of discussions are held policy-wise about the influence of AI and robotics on employment and labor in the US, EU, Germany, France, and China.

AI and robotics are positioned as one of the pillars of economic growth and industrial development in various countries and regions. Development and recruitment of AI-related human resources is also one of the issues discussed. The second half of Part 3 discusses what kind of employment and personnel management systems businesses in Japan and overseas countries are employing. In addition, the report introduces how Japanese are working on human resources development to address changes in the work styles and work environments engendered by AI and robotics while introducing the status of legal systems.

I Employment Policy Trends in the US

1. Introduction

Employment (labor demand) is derived from the demand of economic activities. In general, the "labor market" is a market where employers or recruiters looking to hire workers, and job seekers looking to be employed make deals regarding labor. In this market, the demand and supply for labor are coordinated when prices are determined. Thus, the labor market fulfills the function of optimally allocating resources called labor.[1] Directions of economic activities, such as industrial trends and progresses of technology development, must be understood when it comes to employment policies and labor market laws that are designed as policy interventions with employment systems aiming to establish the foundation for the labor

* The last date of access to the internet information in this paper is May 1, 2018.

[1] Soichi Ota & Toshiaki Tachibanaki, An Introduction to Labor Economics, Yuhikaku, 2004, pp.4, 23-41 (in Japanese).

market and to maximize its function. Hereinafter, this chapter will overview employment policies in relation to artificial intelligence (AI) / robotics and also introduce industrial policies.

Traditionally, it is said that there are two types of stances in policy interventions on the labor market: a passive stance (less regulation) and an aggressive stance (more regulation). The US has been considered a typical example of the passive stance.[2] In other words, the US respects the essential function of the market itself, and the federal government is reserved in implementing regulations and interventions (for example, legal regulations on dismissal).[3] US employment policies have put priority on improving the rate of unemployment and maintaining the average wage level under relaxed regulations on employment but have had to live with a large income gap in exchange.[4] As discussed later, this stance has not changed when it comes to AI and robotics

President Donald Trump assumed the presidency in January 2017, but one year into his presidency, he has not clearly presented policies regarding AI/robotics and labor/employment. Therefore, this chapter will also explain the policy documents released during the former President Barack Obama administration.

2. Policy documents regarding AI, robotics, and employment during the Obama administration

Recently, the possibility of jobs being replaced due to automation and digitalization, such as the use of AI and robotics, has been a hot topic around the globe. Some note that 47% of US workers have professions that are more likely to be replaced by AI within 10 to 20 years.[5] It is said that nonroutine tasks, which have not been considered be likely to be replaced by machines, will also be performed by machines due to advancements in big data and AI. As seen in *Race against the machine*,[6] which has attracted much attention, some say that people are losing jobs because people or society cannot fully handle technology, as technologies, not just AI and robotics, are progressing rapidly. The US is concerned that labor demand may change owing to the automation of production activities, which may have a negative impact on employment and labor.

In October 2016, the National Science and Technology Council (NSTC) and the Office of Science and Technology Policy (OSTP), which are organizations for gathering information on the science and technology policies of various departments and agencies and for ensuring coordination among them, published a report entitled "Preparing for the Future of Artificial Intelligence."[7] This report presents the social impacts of AI and a framework for designing institutional arrangements. It is important to understand this report together with the "National Artificial Intelligence Research and Development

---

[2] Yasuo Suwa, *Employment Policies and the Rights to Career: Exploring Career Law*, Koubundou, 2017, pp.19-20 (in Japanese).

[3] In most cases, this works closely with the principles of control and intervention in the economy in general. Same as above.

[4] Akihisa Adachi, "International comparison of employment protection regulations (Volume 1): Protection regulations in 23 major OECD member countries and quantitative analysis of socio-economic factors," *Journal of Faculty of Business Administration, Tokoha University* Vol.4 No. 2, 2017.2, p.1 (in Japanese). <https://tokoha-u.repo.nii.ac.jp/?action=repository_uri&item_id=1272&file_id=22&file_no=1>.

[5] Carl B. Frey and Michael A. Osborne, "The future of employment: how susceptible are jobs to computerization?" *Technological Forecasting and Social Change*, Vol.114, 2017.1, pp.254-280.

[6] Erik Brynjolfsson and Andrew McAfee, *Race against the machine: How the digital revolution is accelerating innovation, driving productivity, and irreversibly transforming employment and the economy*, 2011.

[7] National Science and Technology Council et al., "Preparing for the Future of Artificial Intelligence," 2016.10. Obama White House Website <https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf>.

Strategic Plan"[8] formulated at the same time. Social issues were explored in "Preparing for the Future of Artificial Intelligence" in alignment with the exploration of industrial policies and R&D strategies in the "National Artificial Intelligence Research and Development Strategic Plan," and as one of the social issues, employment policies in relation to AI were analyzed. Therefore, the report "Preparing for the Future of Artificial Intelligence" highlights social issues arising from the advancement of AI and its use and dissemination, but it also anticipates benefits engendered by AI. While promoting R&D in the field of AI, it maintains a consistent perspective when it comes to how to control these social issues, exhibiting an optimistic tone overall.[9] The report makes 23 recommendations, including the promotion of innovation, support for basic research, monitoring of safety and equality, use of AI by the government, international collaboration, and implementation of cyber security. There was also a recommendation for compiling a follow-on report by the end of 2016 regarding the impact on the economy and employment.

In response to this, the Executive Office of the President released a report entitled "Artificial Intelligence, Automation, and the Economy"[10] in December 2016. The report said that improvements in labor productivity and GDP growth could be expected from AI and automation. It presents a vision that there will be both creation and loss of jobs, but there will not be a significant change in the rate of unemployment as a result.[11] On the other hand, it notes that AI and automation may lead to economic inequality and widened economic gaps because the skills required in the labor market will change, and in particular, the jobs of workers with low wages, low skills, and low education will be threatened.[12] It suggests that the US should undertake long-term policy interventions, namely, (1) investing in R&D of AI, (2) investing in education and training, and (3) establishing and reinforcing safety nets, such as unemployment insurance and support for re-employment.

3. Innovation and employment trends

There is a reason for the optimism seen in "Artificial Intelligence, Automation, and the Economy." What has significantly contributed to growth in real GDP since 2000 is total factor productivity (TFP),

---

[8] National Science and Technology Council et al., "The National Artificial Intelligence Research and Development Strategic Plan," 2016.10. Obama White House Website <https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/national_ai_rd_strategic_plan.pdf>.

[9] Chris O'Brien, "White House: 'A.I. holds the potential to be a major driver of economic growth and social progress'," *VentureBeat*, 2016.10.12. <https://venturebeat.com/2016/10/12/white-house-a-i-holds-the-potential-to-be-a-major-driver-of-economic-growth-and-social-progress/>.

[10] Executive Office of the President, "Artificial Intelligence, Automation, and the Economy," 2016.12. Obama White House Website <https://obamawhitehouse.archives.gov/sites/whitehouse.gov/files/documents/Artificial-Intelligence-Automation-Economy.PDF>.

[11] Other studies also predict that there will not be much of a decrease in the number of jobs. For example, previous research notes that jobs will consist of various tasks and that over 70% of tasks can be automated in only 9% of professions, under the assumption that the possibilities of mechanization should be estimated by task, not profession. Melanie Arntz et al., "The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis," *OECD Social, Employment, and Migration Working Papers*, No.189, 2016, pp.47-54. <http://dx.doi.org/10.1787/5jlz9h56dvq7-en>; previous research also suggests that there will not be a significance decrease in jobs through automation and that the content of tasks is highly likely to change. OECD, "Automation and Independent Work in a Digital Economy," 2016.5, OECD Website <https://www.oecd.org/els/emp/Policy%20brief%20-%20Automation%20and%20Independent%20Work%20in%20a%20Digital%20Economy.pdf>.

[12] During technological innovation in the 19th century, highly skilled workers (experienced craft workers) were replaced both by low skilled workers and machines, but during technical innovation in the latter half of the 20th century, routine tasks were replaced, and the demand for highly skilled workers increased, which is consistent with history. Executive office of the President, *op.cit.*(10), p.11.

which indicates the increase in productivity irrelevant of the increase in capital and labor, and "innovation"[13] is what has driven the increase in TFP.[14] There are information and communication giants, such as Google, Apple, Facebook, and Amazon, in the US, and their innovations have contributed to the growth in real GDP. Yet, the number of employees working in the information and communication industry is only 2,720,000 (as of November 2017), which accounts for only about 2.1% of all workers.[15]

On the other hand, if we look at robot-related manufacturing businesses, the number of employees working in the manufacturing industry is about 12,510,000 (as of November 2017), but this figure has been on the decline since the 2000s; the share of employees on nonfarm payrolls has dropped to 8.5% of all workers.[16] This is mainly because import competition with China has negatively affected employment.[17] In other words, one of the reasons for this is the increased globalization of corporate activities, such as "offshoring," which is the practice of transferring relatively low priority jobs to overseas countries and concentrating on relatively high priority jobs within the country. A similar situation with respect to the international division of labor and decrease in domestic employment seen with "offshoring" in the manufacturing industry can also occur with AI and robotics-based automation.

4. Trends seen in the Trump administration

President Trump was elected because he recognized the downfall of manufacturing businesses in areas surrounding the Great Lakes called the "Rust Belt" as a problem,[18] and he publicly promised to create 25,000,000 jobs within 10 years by reviewing tax cuts, investment in infrastructure, and trade relations.[19]

However, for example, Secretary of the Treasury Steven Mnuchin said in March 2017 that jobs of American people will not be taken away through AI and robotics-based automation until 50 or 100 years from now.[20] Thus, insufficient attention has been devoted to the issues presented in "Artificial Intelligence, Automation, and the Economy" released during the Obama administration. This statement by

---

[13] OECD and European Communities, *Oslo Manual: Guidelines for Collecting and Interpreting Technological Innovation Data, 3rd Edition*, Paris: OECD Publishing, 2005, p.46. <http://dx.doi.org/10.1787/9789264013100-en>. This includes not only technological innovation but also on-technological innovation, such as the improvement of promotion methods and renewal of management strategies, in innovation. In other words, creating new value by improving work efficiency through organizational reforms and applying existing technologies that have been disseminated widely and that have become reasonable in other areas can lead to an increase in TFP and eventually to economic growth.

[14] Ministry of Health, Labour and Welfare, "2017 Analysis of the labor economy: Challenges for Promoting Innovations and Realizing Work-Life Balance, Overview" 2017. < http://www.mhlw.go.jp/english/wp/l-economy/2017/summary.pdf >.

[15] "Industries at a Glance: Information: NAICS 51." U.S. Bureau of Labor Statistics Website <https://www.bls.gov/iag/tgs/iag51.htm>,

[16] "The Employment Situation - November 2017," 2017.12.8. U.S. Bureau of Labor Statistics Website <https://www.bls.gov/news.release/archives/empsit_12082017.htm>. The number of employees on nonfarm payrolls (seasonally adjusted) is about 147,240,000 (as of November 2017).

[17] Daron Acemoglu et al., "Import competition and the great US employment sag of the 2000s," *Journal of Labor Economics*, Vol.34 No.S1, 2016.1, pp.S141-S198; Cabinet Office, *Trend of World Economy 2017 I: Globalization, economic growth, and employment*, 2017.7, p.36. <http://www5.cao.go.jp/j-j/sekai_chouryuu/sh17-01/pdf/s1-17-1-3.pdf> (in Japanese).

[18] The decline of the employment situation in the Rust Best is considered to be caused by the unique circumstances of the area; for example, high wage levels were maintained due to the existence of strong labor unions, and structural adjustment was not successfully completed. Simeon Alder et al., "Labor Market Conflict and the Decline of the Rust Belt," Manuscript, University of California, San Diego, 2017.2.4. <https://sites.google.com/site/davidlagakos/home/research/rustbeltrevision_submit.pdf>.

[19] "New US administration taking tough stance toward employment expansion, using return of the manufacturing industry as the driving force to overcome invisible low growth," *Nihon Keizai Shimbun*, 2017.1.21, p.2 (in Japanese).

[20] Chris Weller, "Trump's Treasury secretary revises claim the prospect of robots displacing humans," 2017.5.25. Business Insider Website <http://www.businessinsider.com/trump-administration-robot-automation-2017-5>.

the Secretary of the Treasury was corrected in May 2017. Yet, no policies regarding AI/robotics and employment/labor have been presented during the first year of Trump's presidency.

5. Introduction of AI in employment and recruitment and the use of personal data

"HR Tech (Human Resource Technology)" has been attracting attention recently. This involves the use of information technology to improve tasks in the domain of personnel affairs. However, some are concerned about "profiling" during the recruitment process,[21] which is a problem where unexpected stigma may be placed on competence of workers if companies use AI to have it analyze information on job applicants, their circle of friends, and their action history publicly available on social network services (SNS) so that companies can hire people based on a probabilistic certainty.

A report released by the Federal Trade Commission (FTC) in January 2016 entitled "Big Data: A tool for inclusion or exclusion?"[22] and a report released by the Executive Office of the President in May 2016 entitled "Big Data: A Report on Algorithmic Systems, Opportunity, and Civil Rights"[23] express concern that the use of big data and AI may lead to the elimination and discrimination of job applicants. For example, the FTC's report notes that if past results regarding personnel management and evaluation are used to develop AI for helping determine good candidates and if such results contain biases with respect to race, gender, or academic background, such biases will be reproduced, and discrimination may inherently result.[24]

The private sector has also raised issues and has been exploring solutions. The Institute of Electrical and Electronics Engineers (IEEE), a society of electrical and electronic engineering in charge of setting standards and standardization, launched a program called the "IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems" in April 2016.[25] The institute released its first report, entitled "Ethically Aligned Design: A Vision For Prioritizing Wellbeing With Artificial Intelligence And Autonomous Systems," in December 2016.[26] This report addresses issues related to the use of personal data, which is not only information on individuals but also information that cannot be used for personal identification, such as device information and location information. Therefore, standards such as the "Standard for Transparent Employer Data Governance" are now being discussed.[27]

In January 2017, the Future of Life Institute (FLI), an organization supporting efforts toward the effective use of new technologies such as AI, held a five-day international conference in Asilomar,

---

[21] Tatsuhiko Yamamoto, "AI and 'Respect for Individuals'," Masaki Fukuda et al. (eds.), *Society Connected by AI: Laws and policies in the era of AI network*, Koubundou, 2017, pp.320-343 (in Japanese).

[22] Edith Ramirez et al., "Big Data: A Tool for Inclusion or Exclusion?" *FTC Report*, 2016.1. Federal Trade Commission Website <https://www.ftc.gov/system/files/documents/reports/big-data-tool-inclusion-or-exclusion-understanding-issues/160106big-data-rpt.pdf>.

[23] Executive Office of the President, "Big Data: A Report on Algorithmic Systems, Opportunity, and Civil Rights," May 2016. Obama White House Website <https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/2016_0504_data_discrimination.pdf>.

[24] Edith Ramirez et al., *op.cit.*(22), pp.28-29.

[25] "The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems." IEEE Standards Association Website <http://standards.ieee.org/develop/indconn/ec/autonomous_systems.html>.

[26] IEEE, "Ethically Aligned Design: A Vision for Prioritizing Human Wellbeing with Artificial Intelligence and Autonomous Systems, Version 1 – For Public Discussion," 2016.12.13. <http://standards.ieee.org/develop/indconn/ec/ead_v1.pdf>.

[27] "7005 - Standard for Transparent Employer Data Governance." IEEE Standards Association Website <https://standards.ieee.org/develop/project/7005.html>.

California,[28] to discuss the direction of AI studies, ethics and values, and future issues while referring to various discussions held in the past, principles, and guidelines. The institute released the outcome of the conference in the report "Asilomar AI Principles."[29] Among them, the following three principles are based on problems related to the use of personal data and respect for individuals.

- Human Values: AI systems should be designed and operated so as to be compatible with ideals of human dignity, rights, freedoms, and cultural diversity.
- Personal Privacy: People should have the right to access, manage, and control the data they generate, given AI systems' power to analyze and utilize that data.
- Liberty and Privacy: The application of AI to personal data must not unreasonably curtail people's real or perceived liberty.

6. Summary

In the US, AI and robotics are expected to drive economic growth. At least during the Obama administration, policies to promote innovation were discussed. Points of argument related to social issues raised by AI were summarized, and the issue of employment and labor was discussed by the Executive Office of the President. Back in 2016, the Executive Office of the President determined that the loss of jobs due to AI and robotics would be compensated for by the level of job creation and that the unemployment rate would change significantly. It also suggested establishing safety nets in this respect, such as investing in education and training, reinforcing unemployment insurance, and supporting re-employment, because the skills required in the labor market would likely change. However, since Trump's inauguration, policies regarding AI/robotics and employment/labor have not been presented.

During the Obama administration, the Executive Office of the President and FTC put together a report summarizing the points of argument regarding the introduction of AI and the use of personal data during the processes of employment and recruitment. Discussions are also being held in the private sector; for example, the IEEE is considering standards to realize the equal, fair, and transparent use of data.

Fumiko Kudo, Makaira KK

II Employment Policy Trends in the EU and Germany

1. Introduction

This chapter will overview the employment policy trends in the European Union (EU). As discussed in the previous chapter, the US has taken a passive stance (less regulation), but it is said that continental European countries (e.g., Germany, Northern Europe, and France) are taking an aggressive stance (more regulation).[30] In other words, on the lookout for the "failure of the market," they are proactive in preparing sufficient safety nets (e.g., unemployment insurance system, job training system) and introducing

[28] "Beneficial AI 2017." Future of Life Institute Website <https://futureoflife.org/bai-2017/>.
[29] "Asilomar AI Principles." Future of Life Institute Website <https://futureoflife.org/ai-principles-japanese/>.
[30] Suwa, *op.cit.* (2), pp.19-20.

regulations related to social and labor law (e.g., employment control, maintenance of individual employment, legal regulation on dismissal). Moreover, generally, continental European countries have adopted stringent regulations on employment protection while putting priority on reducing the income gap and raising the average wage. In exchange for this, they have had to live with a high rate of unemployment.[31] In addition to employment policy trends in EU, we will also introduce industrial policies and employment policies in Germany, a representative country with an aggressive stance.

As discussed later, regarding the relationship between AI/robotics and employment/labor, the EU sees that jobs will increase in the future from the use of AI/robotics. To address the possibility that there may be changes in the demand for occupational skills and job content, the EU is discussing policies related to the development of occupational skills aligned with social security systems and group labor relations law (laws pertaining to labor unions and labor relations coordination).

2. Policy trends in the EU pertaining to AI, robotics, and employment

In January 2015, the "Working Group on Robotics and Artificial Intelligence" was established within the European Parliament's Committee on Legal Affairs.[32] In June 2016, the office of Science and Technology Options Assessment (STOA) of the European Parliamentary Research Service (EPRS) released a report[33] analyzing the risks posed by the advancement of robot technology so that it could contribute to the discussions of the working group. The discussions continued based on this report. In January 2017, the Committee on Legal Affairs put together a report with "Recommendations to the Commission on Civil Law Rules on Robotics."[34] The report notes that it is important to ensure legal stability to develop AI and robotics-related businesses, with the conclusion that it is necessary to introduce uniform civil law regulations within the EU to ensure safety.[35] The report also refers to various risks, including the loss of jobs, widening of gaps, decrease in tax revenue, and damage to social security systems. If the number of human jobs will decrease along with the spread of robotics, social security premiums and tax revenues will go down, and there will be a greater need again to invest in education and training for unemployed people. Therefore, the report suggests that the European Commission should consider

---

[31] Adachi, *op.cit.* (4), p.1 (in Japanese).

[32] "Subject files: Working Group on Robotics and Artificial Intelligence," 2016.11.18. European Parliament Website <http://www.europarl.europa.eu/committees/en/juri/subject-files.html?id=20150504CDT00301>.

[33] Scientific Foresight Unit (STOA), European Parliamentary Research Service, "Scientific Foresight study: Ethical Aspects of Cyber-Physical Systems," PE 563.501, 2016.6. <http://www.europarl.europa.eu/RegData/etudes/STUD/2016/563501/EPRS_STU(2016)563501_EN.pdf>.

[34] Committee on Legal Affairs, *Report with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL))*, PE582.443v03-00, European Parliament, 2017.1.27. <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+REPORT+A8-2017-0005+0+DOC+PDF+V0//EN>. The Committee usually appoints a "Rapporteur" for each case, and the Rapporteur puts together a report to be submitted to the plenary session. The Rapporteur of this case was Mady Delvaux, a member of the Parliament from Luxembourg, who belongs to the Progressive Alliance of Socialists and Democrats (S&D), a left-center party and the second party of the European Parliament.

[35] Recommendations pertaining to civil law regulations are diverse; the report not only includes a "Charter on Robotics" defining robot development principles and usage guidelines but also defines and classifies autonomous robots, clarifies liability for damage caused by autonomous robots and a compulsory insurance scheme for autonomous vehicles, introduces a robot and AI registration system to ensure traceability, and establishes an institution dedicated to providing advice on technological, ethical, and legal problems pertaining to robots. The report also mentions the possibility of giving a specific legal status to robots, namely, the status of "electronic person," for some autonomous robots in the future so that they will be responsible for any damage they may cause. Ikuko Kudo, "Advent of the Concept 'Electric Person' Next to Natural Person and Legal Person," *Bijinesu Homu*, Vol.18 No.2, 2018.2, pp.4-5 (in Japanese).

introducing a "robot tax," by mandating that companies that own robots register AI-equipped robots and pay part of the revenues obtained through the use of robotics as a tax and that it should offer "basic income" to realize sustainable taxation systems and social security systems.

However, following the release of the report, the International Federation of Robotics, to which robot manufacturers around the world belong, as well as the Mechanical Engineering Industry Association (Verband Deutscher Maschinen- und Anlagenbau – VDMA), an organization for machine and plant manufacturers in Germany, expressed opposition to the introduction of a robot tax, asserting that there is a positive correlation between "robot density," which refers to the number of robots per 10,000 workers in one country, and the number of employees, according to statistics from the automotive industry and the like.[36] At the plenary session of the European Parliament, some insisted that levying a robot tax may hamper the dissemination of robots and may lower the competitiveness of EU and its member nations, which would result in a loss of human jobs. Therefore, all descriptions related to a robot tax were erased from the modified report adopted during the plenary session held in February 2017.[37]

As for industrial policies in the EU, the European Commission released the new "Industrial Policy Strategy" in September 2017.[38] The report says that the European Commission will seek to play a leading role in the fields of innovation, digitalization, and decarbonization internationally while emphasizing the necessity to maintain and reinforce industrial competitiveness. Other the other hand, it also says that the commission should pay close attention to how new technologies and new business models would affect labor and employment.

3. Industrial policies in Germany

Manufacturing businesses account for about 20% of GDP in Germany. The contributions from businesses such as transport machinery, general machinery, and electronic and electric equipment to economic growth are very high. Germany thus has an industrial structure with strong manufacturing capabilities. It is said that the manufacturing industry in Germany successfully increased value added to the amount of sales by transferring labor-intensive production processes to Eastern European countries, leaving high-value added production processes in the country, and it worked on branding of high-quality models.[39]

---

[36] "European parliament calls for robot law, rejects robot tax," *Reuters*, 2017.2.17. Website <https://www.reuters.com/article/us-europe-robots-lawmaking/european-parliament-calls-for-robot-law-rejects-robot-tax-idUSKBN15V2KM>.

[37] European Parliament, *Civil Law Rules on Robotics: European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL))*, P8_TA(2017)0051, European Parliament, 2017.2.16. <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+TA+P8-TA-2017-0051+0+DOC+PDF+V0//EN>. The report says that close attention should be paid to the medium- to long-term effects of AI and robotics on employment and labor. Resolutions of the European Parliament (adoption of reports) are not legally binding. Therefore, the European Commission, the only EU agency that has the right to submit law and bills, is not obliged to follow them. The European Commission has started working on setting rules pertaining to the ethical aspect of AI and is planning to present directions to its member nations in the spring of 2018. However, the establishment of regulations will probably be shelved. "AI 'Rules, EU leads' 'personality' 'taxation' Hope for discussions among the members of the parliament," Mainichi Shimbun, 2018.2.8, p.8 (in Japanese).

[38] European Commission, *Investing in a smart, innovative and sustainable Industry A renewed EU Industrial Policy Strategy*, COM(2017) 479 final, 2017.9.13.

[39] Martin Krzywdzinski, "How the EU's Eastern Enlargement Changed the German Productive Model. The Case of the Automotive Industry," *Revue de la régulation*, 15, Spring 2014. <http://regulation.revues.org/10663>.

To further promote such efforts of the industrial arena and maintain and reinforce its international superiority as an exporter, the German federal government also sets a goal for the overall optimization of development, manufacturing, and distribution processes through digitalization in the "High-Tech Strategy 2020 Action Plan"[40] put together in November 2011. This German strategy promoting the digitalization of industries, mainly the manufacturing industry, is widely known as "Industry 4.0 (Industrie 4.0)."[41] "Digital Strategy 2025 (Digitale Strategie 2025),"[42] formulated by the Federal Ministry for Economic Affairs and Energy in March 2016, addresses support for the digitalization of small and medium-sized companies called "mittelstand," which have supported the economic growth of Germany, as one of the ten measures recommended for promoting digitalization.[43] In response to "Digital Strategy 2025," a leading business software company headquartered in Germany, SAP SE, now plays the role of communicant to small- and medium-sized companies in "Industry 4.0" through enterprise resource planning (ERP) systems and consulting services, for example.[44] In other words, Germany is facilitating the digitalization of mittelstand not only by coordinating ERP systems, which are the core systems of such companies, with electronic commerce (EC) and allowing them to adjust production according to the sales order status, but also by facilitating horizontal integration through the integration of systems among companies.

4. Work 4.0 and issues pertaining to occupational skills development in Germany

It has been noted that Germany succeeded in increasing its international competitiveness thanks to the flexible labor market formed by the employment policy turnaround in the 2000s[45] and the low unit labor cost.[46] Because the increase of labor productivity exceeds the rise of wages, Germany kept labor's share of profits (proportion of labor cost in added value) low and established an environment where labor movement among companies or among divisions is easy, which apparently contributed to increasing German companies' competitiveness.

In November 2016, the Federal Ministry for Labour and Social Affairs released a white paper entitled "Work 4.0 (Arbeiten 4.0)."[47] This contains the results of broad discussions among labor relations

---

[40] Federal Ministry of Education and Research, "The new High-Tech Strategy 2020 Innovation for Germany," 2014.8. <https://www.bmbf.de/pub/HTS_Broschuere_eng.pdf>.

[41] Plattform Industrie 4.0 Website <http://www.plattform-i40.de/I40/Navigation/DE/Home/home.html>.

[42] Federal Ministry for Economic Affairs and Energy, Digital Strategy 2025, 2016.4. <https://www.de.digital/DIGITAL/Redaktion/EN/Publikation/digital-strategy-2025.pdf?__blob=publicationFile&v=8>.

[43] Ministry of Internal Affairs and Communications (ed.), *Information and Communications in Japan*, 2017. < http://www.soumu.go.jp/johotsusintokei/whitepaper/eng/WP2017/2017-index.html >.

[44] Japan Machinery Federation, "2014 research of responses to paradigm shift of the global manufacturing industry," 2015.3, pp.112-113. <http://www.jmf.or.jp/content/files/houkokusho/26nendo/26jigyo_08.pdf> (in Japanese).

[45] During the Gerhard Schröder administration, Germany attempted to change the direction of labor policies from unemployment compensation to employment promotion and worked on making the labor market flexible and diverse, under the basic principle to "stimulate and guarantee self-reliant efforts." Cabinet Office, "Trend of World Economy 2016 II: Low interest rate and low inflation in advanced countries, regional gap in China," 2017.1, pp.114-130 (in Japanese). <http://www5.cao.go.jp/j-j/sekai_chouryuu/sa16-02/index-pdf.html>; Japan Institute for Labour Policy and Training, "Labor and employment policies and social security in Germany and France," *JILPT Report*, No.84, 2007.4, pp.11-36 (in Japanese). <http://www.jil.go.jp/institute/reports/2007/documents/084.pdf>.

[46] Bennet Berger and Guntram Wolff, "The global decline in the labour income share: is capital the answer to Germany's current account surplus?" *Policy Contribution*, Issue 12, 2017.4. <http://bruegel.org/wp-content/uploads/2017/04/PC-12-2017-1.pdf>; Cabinet Office, *op.cit.* (45), pp.121, 129.

[47] Bundesministerium für Arbeit und Soziales, *Weissbuch Arbeiten 4.0*, 2017.3. <http://www.bmas.de/SharedDocs/Downloads/DE/PDF-Publikationen/a883-weissbuch.pdf?__blob=publicationFile&v=9> (in German). The following sources were referred to for "Work 4.0" in this chapter: Kenji Takahashi, "Employment policies over IoT and AI in Germany: New debate related to German labor law over Work 4.0," *DIO RengoSouken Report*, No.329, 2017.9,

organizations, intellectuals, and citizens, which began in April 2015,[48] to consider future employment policies in view of "Industry 4.0," as is evident from its title.

"Work 4.0" and "German Labour Market 2030," [49] a survey report put together prior to it, both expect economic growth and an increase in jobs in the labor market, if Germany promotes "Industry 4.0" and focuses on digitalization utilizing AI and robotics (digitalization promotion scenario).[50] Specifically, both argue that although about 750,000 jobs will be lost in 27 areas (e.g., retail, papermaking, printing, public services), about 1 million jobs will be created in 13 areas (e.g., electronic optical machinery, IT, R&D), and there will be an increase of about 250,000 jobs compared to 2014.[51]

Both high-skilled jobs and low-skilled jobs increased from 2002 to 2014 in the EU, Japan, and the US, whereas middle routine jobs, which are jobs for routine tasks decreased, already resulting in bipolarization.[52] "Work 4.0" explains that such bipolarization has not been seen in Germany to this point.[53] However, it shows strong concern over the possibility of job bipolarization and widened gaps among workers in the future.

Bering this forecast in mind, to realize "good-quality jobs" (Gute Arbeit) in the future, "Work 4.0" presents five policy goals, such as maintaining employability over the entire career of each person, even if digitalization changes the labor market and society. As one of the concrete policy challenges, "Work 4.0" cites the improvement of continuous education and training called "Weiterbildung" so that employed workers can maintain and acquire the necessary knowledge and skills according to changes in the external environment. Weiterbildung are currently provided by occupational schools, technical schools, universities, and private organizations such as labor unions, and they are not necessarily appropriate programs. Therefore, "Work 4.0" suggests formulating comprehensive strategies at national-level conferences where the government, labor unions, and companies participate to reconstruct the overall Weiterbildung system. It also suggests covering the cost of education and training with unemployment insurance, stating "from unemployment insurance to insurance for labor."

"Work 4.0" also cites the reinforcement of the labor relations system so that representatives of workers can participate in the processes and procedures for changing work styles and corporate organizations, as an important policy goal to realize "good-quality jobs."

---

pp.26-29. <http://www.rengo-soken.or.jp/dio/pdf/dio329.pdf> (in Japanese); Yota Yamamoto, "Changes in work styles caused by the fourth industrial revolution and issues surrounding labor law policy: What German "Work 4.0" white paper proposes," *Business Labor Trend*, 2017.8 & 9, pp.46-53. <http://www.jil.go.jp/kokunai/blt/backnumber/2017/0809/046-053.pdf> (in Japanese).

48 "Weißbuch Arbeiten 4.0 - Diskussionsentwurf." Arbeiten 4.0 Website (Bundesministerium für Arbeit und Soziales) <http://www.arbeitenviernull.de/dialogprozess/weissbuch.html> (in German).

49 Kurt Vogler-Ludwig et al., *Arbeitsmarkt 2030 - Digitalisierung der Arbeitswelt: Fachexpertisen zur Prognose 2016*, Economix Research & Consulting, 2016. (Im Auftrag des BMAS) <https://doi.org/10.3278/6004559w> (in German). As explanatory mateiral in Japanaese, refer to "Prediction of 2030 labor market: Report commissioned by Federal Ministry for Labour and Social Affairs," 2016.11. Japan Institute for Labour Policy and Training Website <http://www.jil.go.jp/foreign/jihou/2016/11/germany_01.html> (in Japanese).

50 In terms of the labor market prediction, the "base scenario," which is focused on the supply of labor by immigrants against the background of the declining birthrate and aging population, and "digitalization promotion scenario," which is focused on the promotion of digitalization, are analyzed.

51 Bundesministerium für Arbeit und Soziales, *op.cit.*(47), p.48 (in German).

52 OECD, *op.cit.*(11), p.1.

53 Bundesministerium für Arbeit und Soziales, *op.cit.*(47), p.53 (in German).

5. Summary

In Europe, industrial digitalization utilizing AI and robotics is anticipated to drive economic growth. The EU and the German government position this area as one of the pillars of their industrial policies. In terms of the relationship between AI/robotics and employment/labor, the EU presumes that jobs will increase through the promotion of digitalization, and detailed discussions are being held pertaining to social security systems and group labor relations systems so that people can development occupational skills that can adapt to job bipolarization.

Fumiko Kudo, Makaira KK

III AI and Employment Issues in France

1. Occupational consciousness and employment status in France

Occupational consciousness in France is very different from that in Japan. As a national trait of French people, they put great value on leisure and vacation. In France, people do not associate much with their peers after work or on weekends and have a low sense of belonging to their workplace (group).[54] The current French labor law sets working hours at 35 hours per week (1607 hours per year) and maximum 10 hours per day.[55] The law also sets paid vacation time for 2.5 days a month (30 days per year) irrespective of the employment pattern (nonfixed-term employment contract, fixed-term employment contract, temporary employment).[56] The average total working hours per year per French person is low by international standards, and the number of days off per year is high.[57]

They are very conscious about becoming pensioners after retirement, and the employment rate of the elderly is low among major nations.[58]

Regarding the employment status of France, we can see that France has been faced with mass unemployment for the past 30 years.[59] France constantly shows a higher unemployment rate[60] than Japan; the rate was 6.4% in 1980 (2.0% in Japan in the same year), 8.4% in 1990 (2.1% in Japan), 9.2% in 2000 (4.7% in Japan), and 9.3% in 2010 (5.1% in Japan).[61] The overall unemployment rate was 9.3% in the

[54] "Worker consciousness: France, Occupational consciousness of French people," 2005.4. Japan Institute for Labour Policy and Training Website <http://www.jil.go.jp/foreign/labor_system/2005_4/france_01.html>. (in Japanese)

[55] "Durée de travail du salarié à temps plein," 2016.10.28. Service-Public.fr Website <https://www.service-public.fr/particuliers/vosdroits/F1911>. According to Code du travail, L.3121-18, L.3121-27, and L.3121-41. (in French)

[56] "Congés payés," 2017.12.4. Service-Public.fr Website <https://www.service-public.fr/particuliers/vosdroits/F2258>. According to Code du travail, L.3141-3. (in French)

[57] Japan Institute for Labour Policy and Training (ed.), *Data Book: International Labor Comparison 2017*, Japan Institute for Labour Policy and Training, pp.201-202. <http://www.jil.go.jp/kokunai/statistics/databook/2017/documents/Databook2017.pdf>. (in Japanese)

[58] Same as above, pp.78-81.

[59] Marine Rabreau, "Qui sont les chômeurs en France?" *Le Figaro*, 2015.12.16. <http://www.lefigaro.fr/economie/le-scan-eco/decryptage/2015/12/16/29002-20151216ARTFIG00013-qui-sont-les-chomeurs-en-france.php>. (in Japanese)

[60] This refers to the proportion of unemployed people among the labor force population.

[61] "World Economic Outlook Databases (October 2017 Edition)," 2017.10.10. International Monetary Fund Website <http://www.imf.org/external/pubs/ft/weo/2017/02/weodata/index.aspx>.

first quarter of 2017 (2.9% in Japan), and the unemployment rate among young people (aged 15-24) is even higher than that among other age groups, at 21.8%.[62]

2. French government initiatives pertaining to employment and AI

A report published in January 2017 by the Employment Advisory Council (Conseil d'orientation pour l'emploi: COE), which consists of intellectuals, labor relations representatives, representatives of government agencies, and members of parliament under the control of the Prime Minister. The report discusses employment issues in general, presented the council's perception of employment and AI in France as follows.[63]

- Less than 10% of existing jobs are vulnerable to extinction due to AI.
- The contents of half of the current jobs may change significantly due to automation and digitalization.
- Technology progress would continue to favor skilled and highly qualified employment.

Based on this perception, the French Minister for the Digital Sector and Innovation and Minister of Higher Education and Research initiated an activity called "France AI (France IA) in January 2017." In addition to government officials and researchers, representatives of the private sector participated in discussions regarding the (1) status of AI-based innovation, (2) impact on society and the economy, and (3) ways to perform job training and research in the future.[64] A report put together in March 2017 entitled "France IA" states that AI will no doubt significantly change current jobs and economic activities, whereas there is an expectation of employment creation by AI.[65] The report also suggests enriching job training for workers after being employed and creating a society where people can change jobs flexibly.

The report also recommends that France not only develops the use of AI within the country but also takes a leadership role within the EU, and for this purpose it is necessary to build an attractive environment for overseas researchers, investors, and entrepreneurs. In particular, it is aiming for the creation and cultivation of AI-related start-ups (ventures).

At about the same time as "France AI," the Office Parlementaire d'Evaluation des Choix Scientifiques et Technologiques (OPECST), which was established within parliament to evaluate science and technology activities and relevant policies, composed by senators and deputies, published a report

---

[62] The National Institute of Statistics and Economic Studies, ,"The unemployment rate decreased by 0.4 points in Q1", Informations Rapides, No.131, 2017.5.18. <https://www.insee.fr/en/statistiques/2851778>

[63] Conseil d'orientation pour l'emploi, *Automatisation, numérisation et emploi Tome 1: les impacts sur le volume, la structure et la localisation de l'emploi (Synthèse)*, 2017.1, pp.2-3, 7. <http://www.coe.gouv.fr/IMG/pdf/COE_170110_Synthese_du_rapport_Automatisation_numerisation_et_emploi_Tome_1.pdf>. (in French)

[64] "Lancement de France I.A., stratégie nationale en intelligence artificielle," 2017.1.23. Ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation (Website) <http://www.enseignementsup-recherche.gouv.fr/cid112129/lancement-de-france-i.a.-strategie-nationale-en-intelligence-artificielle.html>. (in French)

[65] Ministère de l'économie et des finances et al., *France Intelligence Artificielle - Rapport de synthèse*, Ministère de l'éducation nationale, de l'enseignement supérieur et de la recherche, 2017.3, p.16. <https://www.economie.gouv.fr/files/files/PDF/2017/Rapport_synthese_France_IA_.pdf>. (in French)

containing recommendations similar to "France AI," such as the creation of European Champions and enrichment of education and job training.[66]

3. Supports for start-ups in France

It is said that there are over 280 start-ups utilizing AI in France at the moment.[67] In addition, there have been quite a few start-ups that have continued to succeed and grow in the area of IT in recent years both in France and overseas, such as BlablaCar providing ride-share services (established in 2006), Drivy providing car-sharing services among individuals (established in 2010), and Criteo handling digital ads (established in 2005).

Considering the current situation that these IT-related growth industries and new companies are producing half of new jobs, the French government places great expectations on start-ups and thus launched a support program.[68] Specifically, the initiative "French Tech (La French Tech)" initiated by the French government was launched to facilitate the creation and growth of start-ups in November 2013.[69] French Tech is a collective term for a series of activities where entrepreneurs, investors, financial institutions, research institutions, and government agencies cooperate with each other. It is designed to (1) build a network related to start-ups mainly in major cities, (2) promote the growth of start-ups, and (3) encourage globalization. Concrete activities include "Pass French Tech"[70] for accrediting high-growth businesses and providing prioritized support from participating institutions, "French Tech Visa"[71] for simplifying and expediting visa (entry permit) application procedures for excellent foreign human resources and investors, and "French Tech Hub,"[72] which is an overseas base for supporting the overseas expansion of start-ups. In France, 13 cities where there are very active start-up activities are labeled as "Métropole French Tech."[73] In one of them, La French Tech Rennes St-Malo, the number of new employees in IT-related businesses in 2016 was 950, for example.[74] Moreover, 66 businesses were supported by Pass French Tech between 2015 and 2016, and the number of new employees in 2015 was

---

66 Claude De Ganay and Dominique Gillot, *Pour une intelligence artificielle maîtrisée, utile et démystifiée - Tome I*, L'Office parlementaire d'évaluation des choix scientifiques et technologiques, 2017.3.15, pp.121, 209-210. <http://www.senat.fr/rap/r16-464-1/r16-464-11.pdf>. For the summarized version of this report in English, see Claude De Ganay and Dominique Gillot, *Toward a Controlled, Useful and Demystified Artificial Intelligence*, L'Office parlementaire d'évaluation des choix scientifiques et technologiques, 2017.4. <http://www.senat.fr/rap/r16-464-1/r16-464-1-syn-en.pdf>.

67 "Discover 250+ French startups leveraging AI in a variety of applications." France is AI (Website) <http://franceisai.com/startups/>.

68 Shigeo Okamoto, "French government focusing on start-ups," *Telecommunication*, 2016.11, p.64. National Institute of Information and Communications Technology Website <https://www.nict.go.jp/global/pdf/TC201611.pdf>. (in Japanese)

69 "La French Tech: une ambition collective pour les start-up françaises," 2017.5.15. (Last Update) Gouvernement.fr Website <http://www.gouvernement.fr/action/la-french-tech-une-ambition-collective-pour-les-start-up-francaises>. (in French)

70 "Pass French Tech." La French Tech (Website) <http://www.lafrenchtech.com/en-action/pass-french-tech>. (in French)

71 "What is French Tech Visa?" French Embassy in Japan Website <https://jp.ambafrance.org/article11805>; French Tech Visa Website < https://visa.lafrenchtech.com/>.

72 "Les Hubs French Tech à l'international," La French Tech Website <http://www.lafrenchtech.com/en-action/les-french-tech-hubs-linternational>. (in French)

73 "Les Métropoles French Tech" La French Tech Website <http://www.lafrenchtech.com/en-action/le-label-metropoles-french-tech>. (in French)

74 "French Tech Rennes: 950 emplois créés dans le numérique en 2016," *La Tribune*, 2017.4.15. <https://www.latribune.fr/regions/bretagne/french-tech-rennes-950-emplois-crees-dans-le-numerique-en-2016-685922.html>. (in French)

1,123.[75] The number of new start-ups increased by 30% to 9,400 between 2012 and 2015 (the increase in general new companies was 3% during the same period).[76]

Further, Xavier Niel, who is a founder of a leading communication company in France called Iliad, invested 250 million euro (about 33.3 billion yen[77]) of his own money and started the world-largest incubation facility with a 3,000-seat office space called "Station F" in June 2017.[78]

As a result of these public-private initiatives, the total amount invested in ventures in France doubled from 1 billion euro (about 133 billion yen) in 2014 to 2.4 billion euro (about 319 billion yen), and young people are more motivated to start new companies, which resulted in over 10,000 start-ups.[79]

4. Empirical experiment of a new economic system

In addition to efforts to create new businesses like French Tech and to promote industrial digitalization, France is working on an experiment of a new economic model to address changes in society and the economy caused by AI. For example, in Seine-Saint-Denis department, a suburb of Paris, an empirical experiment is being conducted to assess a new system called "le revenu contributif," which replaces conventional salary as a payment for labor performed.[80] This is modeled after a freelance system called "régime d'intermittent du spectacle."[81] Here, individuals' activities that benefit the community, such as volunteer activities or participation in social activities (e.g., road construction), are calculated as activity hours to receive benefits (e.g., vacation, unemployment allowance, job training, pension) of social rights (droit social).[82]

Naoko Abe, Ecole des Hautes Etudes en Sciences Sociales

IV AI, Robotics, and labor in the Chinese Workplace

1. The IT and Internet Industries Create New Employment Trends in China

In 2017, the Chinese government announced a registered unemployment rate of 3.95% in Chinese cities. It is the lowest one in years. Accounting for the decrease is the creation of 7.35 million new jobs in the first half of 2017, an increase of 180,000 jobs compared to the first half of 2016. Despite these

---

75 Rapport d'activité 2015-2016, L'agence du numérique Website <https://agencedunumerique.gouv.fr/wp-content/uploads/2017/03/20170321_Rapport-dactivite-Agence-du-Numerique.compressed-2.pdf>. (in French)

76 *Ibid.*

77 Converted at 1 euro = 133 yen (Ministerial ordinance rate for December 2017). The same applies hereinafter.

78 Station F (Website) <https://stationf.co/>; "Counter attack of the French digital industry: Volume 2, World largest VB base about to become reality, connecting entrepreneurs and investors," Nikkei Sangyo Shimbun, 2017.6.21, p.7. (in Japanese)

79 French Tech Visa Website *op.cit.*(71)

80 "Plaine commune veut tester le revenu contributif," 2017.1.11. Le Parisien Website <http://www.leparisien.fr/villetaneuse-93430/plaine-commune-veut-tester-le-revenu-contributif-11-01-2017-6554634.php>.

81 In régime d'intermittent du spectacle, actors, dancers, musicians, technicians, and so forth working in the entertainment industry can receive support and unemployment allowances from the government if they work 507 hours per year. They can receive the benefits for 12 months from the day of the termination of their contract in principle, but this varies a little by job type. The amount of compensation varies according to the work hours and the wages received during employment. "Indemnisation chômage des intermittents du spectacle: conditions à remplir," 2017.5.12. Service-Public-Pro.fr Website <https://www.service-public.fr/professionnels-entreprises/vosdroits/F14098>. (in French)

82 "Revenu de base et revenu contributif, deux projets complémentaires," 2016.1.9. Mouvement Français Pour un Revenu de Base Website <http://revenudebase.info/2016/01/09/9294/>. (in French)

improvement, the Chinese government is still concerned with: 1) the lack of skilled labor, and 2) the re-employment of laid-off workers.[83]

These concerns are further echoed by 97% of Chinese employers surveyed by Hays, a global recruitment firm, noting their struggle to find skilled workers and predicted the situation will likely worsen[84]. Perhaps accounting for the difficulty in attracting skilled labor, is a large wages gap between the real increase in wage and workers' growing wage expectations outside of competitive industries.[85] Looking at the average salary by industry in 2016, it appears that the IT industry now exceeds the financial industry, which is the highest paying among all industries. Other industries do not appear to be offering similar increases, making other industries less competitive for skilled workers.[86] And yet, the IT industry in China is still unable to fill its ranks with local workers. Despite offering competitive salaries and lucrative positions, it faces a shortage of suitable candidates.

The concerns expressed by both government officials and surveyed employers about the acute shortage in skilled labor can be attributed to the meteoric rise of labor demand in the IT and Internet sectors, which still exceed skilled labor supply. In the second quarter (Q2) of 2017, a survey conducted by the China Institute for Employment Research at Renmin University and Zhaopin limited, a Chinese career platform, concluded that Chinese labor demands exceed labor supply across numerous industries. The "Internet and e-commerce" sectors top that list, as labor demand in the IT and Internet sectors increased by 36% in Q2 of 2017, as compared to Q2 of 2016.[87]

Aware of this occupational predicament, the Chinese university system has already began preparing the next generation of skilled workers for a hi-tech career. A survey by Universum Global, an international human resource consulting company, shows that the most popular industries for Chinese graduate students in 2017 were the IT and Internet sectors, which include e-commerce and social media platforms, among other lucrative businesses. Following the same trend, the survey showed that the popularity of the information and communication technology (ICT), and software industries is also increasing.[88]

In line with China's growing labor market needs, the Chinese Premier, Li Keqiang, declared a boost for "mass entrepreneurship and innovation", and both central and local the Chinese governments have announced several venture support measures, including the establishment of a large fund for venture investments.[89] As aid to manual industrial production decreases with growing automation, local

---

83 "China reports lowest urban unemployment rate in recent years," Xinhuanet, 2017.7.28. <http://news.xinhuanet.com/english/2017-07/28/c_136480724.htm>

84 Maggie Zhang, "Hays survey expects more, better paid Chinese jobs in 2017," South China Morning Post, 2017.2.17. <http://www.scmp.com/business/china-business/article/2071805/hays-survey-expects-more-better-paid-chinese-jobs-2017>

85 *ibid.*

86 Eva Li, "It's official: China's highest-paying jobs have shifted to tech from finance," South China Morning Post, 2017.5.31. <http://www.scmp.com/news/china/economy/article/2096312/its-official-chinas-highest-paying-jobs-have-shifted-tech-finance>

87 Zhaopin Limited, "China labor market continued to improve in the second quarter of 2017," 2017.7.20. PR Newswire Website <https://www.prnewswire.com/news-releases/china-labor-market-continued-to-improve-in-the-second-quarter-of-2017-300491357.html>

88 Universum, *China's Most Attractive Employers 2017*, 2017, p.9. <http://universumglobal.com/rankings/china>

89 "China to further promote innovation and entrepreneurship," 2017.7.12. The People's Republic of China The State Council Website <http://english.gov.cn/premier/news/2017/07/12/content_281475723086902.htm>; 国务院「国务院关于大力推进

governments are also instructed to create funds to support graduate students in opening independent businesses and offer single grants to job seekers who demonstrate difficulties in finding employment. In addition, local governments will be extending internship subsidiaries to students in secondary occupational schools, distant and poverty-stricken areas, and old industrial centers outmatched by automation.[90]

2. Concerns about Job Loss and Automation

The Chinese Manufacturing Promotion Plan, "Made in China 2025",[91] is aiming at creating an innovative manufacturing industry by utilizing China's growing IT industry to improve the efficiency, product quality, and volume of Chinese manufacturing and production. This plan is more essential for the Chinese economy than meets the eye. While the hi-tech industry has many jobs and not enough qualified employees, the manufacturing industry is also struggling with many jobs and fewer candidates. But this shared struggle is caused by the opposite reason, an increase in over-skilled workers with higher salary expectations. As such, automation is crucial for Chinse industrial productivity.

A survey led by Wuhan University found that increasing salaries and labor mobility rates make it impossible for Chinese factories to stay profitable, with many going out of business. In response, 40% of surveyed employers have turned to automated manufacturing and production.[92] Overall, reports show that over 600 companies are looking to automate their factories in China to reduce costs and increase efficiency. This will further exacerbate China's unemployment problem, as robots purchasing rates continue to rise among Chinese companies.[93] IT research company IDC predicts the industrial robots market worth will reach almost 60 billion USD by 2020, with China accounting for 30% of the global market.[94] This makes China the world's largest country in terms of automation demand and consumption.[95]

A report by the German Mercator Institute for China Studies addresses the implications of such massive job loss to automation, and claims that the Chinese government is not yet ready to integrate

---

大众创业万众创新若干政策措施的意见」（国发〔2015〕32 号）2015.6.16. <http://www.gov.cn/zhengce/content/2015-06/16/content_9855.htm>

90 "More job assistance to focus on vital areas," 2017.4.9. The People's Republic of China The State Council Website <http://english.gov.cn/premier/news/2017/04/06/content_281475618173320.htm>

91 国务院「国务院关于印发《中国制造 2025》的通知」（国发〔2015〕28 号）2015.5.8. <http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm>, Scott Kennedy, "Made in China 2025," 2015.6.1. Center for Strategic and International Studies Website <https://www.csis.org/analysis/made-china-2025>

92 "China Employer-Employee Survey Releases First Report," 2017.6.20. Hong Kong University of Science and Technology Institute for Emerging Market Studies Website <http://iems.ust.hk/updates/press-release/china-employer-employee-survey-releases-first-report>

93 Mandy Zuo, "Rise of the robots: 60,000 workers culled from just one factory as China's struggling electronics hub turns to artificial intelligence," *South China Morning Post*, 2016.5.21. <http://www.scmp.com/news/china/economy/article/1949918/rise-robots-60000-workers-culled-just-one-factory-chinas>

94 Bien Perez, "Manufacturing automation to drive China's robotics spending to US$59b by 2020, says IDC," 2017.4.4. South China morning Post <http://www.scmp.com/tech/china-tech/article/2084740/manufacturing-automation-drive-chinas-robotics-spending-us59b-2020>

95 International Federation of Robotics, Executive Summary World Robotics 2017 Industrial Robots, 2017, p.23. <https://ifr.org/downloads/press/Executive_Summary_WR_2017_Industrial_Robots.pdf> However, the number of industrial robots operated per 10,000 workers (referred to as "robot density") is about the same as 66 units in the year 2016, and there are considerable differences from 66 units in the world, Korea (No. 1 in the world), 631 units in Germany, 309 units in Germany (third largest in the world), and 303 units in Japan (fourth largest in the world). 「外经济学家：中国机器人出货量猛增 将对全球经济造成威胁」2017. 8. 24. 中国机器人产业联盟 <http://cria.mei.net.cn/news.asp?vid=3680>

unskilled workers back into the workforce after losing their now automated jobs. This is due to lacking, but much needed, mid-career training schemes. The authors also question the ability of the technology to produce as many jobs as it takes in the short run. This leaves many unskilled workers with employment insecurity, and will likely burden the Chinese government and its plans to achieve smart automation by 2025.[96]

3. China's Plans to Become an AI-Enhanced Nation

Investments in AI in China continue to increase.[97] The State Council of the People's Republic of China has released its new "Next Generation of AI development plan"[98] on July 20th, 2017. The plan is set to address three key aspects of cultivating a robust Chinese AI market: 1) allocating resources to basic research and development, 2) investing in key AI applications for private and public products, and 3) supporting the growth of a robust AI industry through positive regulation and financial means. This plan also looks to attract new talent from overseas, synergize China's commercial and military AI applications, and invest in education and training to enhance the quality and quantity of Chinese talent.

With labor demand already far exceeding supply in the Chinese AI market, companies are showing notable global expansion with many opening AI labs overseas and bringing foreign AI experts to China. Many Chinese companies are rapidly diversifying their business by utilizing AI, and are therefore investing heavily into dominating the field at home and abroad by competing for talent and product development.[99] In addition, China is now ranked second in the world in the number of patent applications related to artificial intelligence. The country is experiencing a meteoric rise in AI development due to the abundance of data available from an estimate of 1.4 billion citizens, collected and analyzed by AI-oriented local IT and Internet companies.[100] China is catching up on basic AI research as well. In 2016, it surpassed the US and became the world's largest producer of academic papers mentioning 'deep learning',[101] and more fundamental research on AI is starting to take place at a growing number of Chinese universities.[102]

Further supporting China's emphasis on basic research, the Chinese minister of Science and Technology announced that a special government fund to promote fundamental research and support the

---

[96] Jost Wübbeke et al., "Made in China 2025: The making of a high-tech superpower and consequences for industrial countries," *MERICS Papers on China*, No.2, 2016.12, p.8. <https://www.merics.org/sites/default/files/2017-09/MPOC_No.2_MadeinChina2025.pdf>

[97] Mark Bergen and David Ramli, "China's plan for world domination in AI isn't so crazy after all," Bloomberg Technology, 2017.8.15. <https://www.bloomberg.com/news/articles/2017-08-14/china-s-plan-for-world-domination-in-ai-isn-t-so-crazy-after-all>

[98] 国务院「新一代人工智能发展规划的通知」2017.7.20. <http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm>

[99] Meng Jing, "Chinese firms fight to lure top artificial intelligence talent from Silicon Valley," *South China Morning Post*, 2017.4.2. <http://www.scmp.com/tech/china-tech/article/2084171/chinese-firms-fight-lure-top-artificial-intelligence-talent-silicon>

[100] "China may match or beat America in AI," *Economist*, 2017.15. <https://www.economist.com/news/business/21725018-its-deep-pool-data-may-let-it-lead-artificial-intelligence-china-may-match-or-beat-america>

[101] Brian Fung, "China has now eclipsed us in AI research," Washington Post, 2016.10.13. <https://www.washingtonpost.com/news/the-switch/wp/2016/10/13/china-has-now-eclipsed-us-in-ai-research/>

[102] Sarah Zhang, "China's artificial intelligence boom," Atlantic, 2017.2.16. <https://www.theatlantic.com/technology/archive/2017/02/china-artificial-intelligence/516615/>

"Next Generation of AI development plan" will be established.[103] Alongside strong government support for basic research, China's industry is also taking initiative in this area alongside universities. A case in point of this trend in academic – industrial collaboration is the establishment of China's first national lab for brain-like artificial intelligence at the China University of Science and Technology. This lab was established in collaboration with Fudan University, the Shenyang Institute of Automation at the Chinese Academy of Science, and Baidu, one of China's largest Internet companies and AI leader.[104]

4. The Ethical Discussion of AI in China

The "Next Generation of AI development plan" calls to "launch research on AI behavior science and ethics and other issues, establish an ethical and moral multi-level judgement structure and human-computer collaboration ethical framework." It also calls to "develop an ethical code of conduct and R&D design for AI products, strengthen the assessment of the potential hazards and benefits of AI, and build solutions for emergencies in complex AI scenarios."

However, the ethical discussion of AI technologies in China is still in early stages, and is in the process of assuming a Chinese identity according to social needs and government planning. Since the publishing of the plan, the Tencent Research Institute has launched the "AI for Social Good",[105] and a number of local Chinese conferences have hosted speeches and panels about the topic in recent months.[106] More debates are starting to emerge in private Chinese circles with growing interest in the field.

Finally, it is important to note that the plan also stresses the need to develop AI in a controllable manner to ensure safety and minimize potential risks. This implies that in the future, discussions on AI ethics and regulation, applied to Chinese ethical thought and governance frameworks, will become more common and robust in China.

Danit Gal, Keio University

V Technological Innovation and Employment

In this and next few chapters, we will overview arguments regarding the cultivation, use, and management of human resources. We will describe what kind of personnel affairs, employment, and management systems today's businesses employ to use and manage human resources with respect to changes caused by AI in work styles and work environments, and we will introduce cases both in Japan and overseas. We will also discuss the statuses of support and regulations from the legal and institutional perspective.

---

[103] Meng Jing, "Beijing to release national artificial intelligence development plan," South China Morning Post, 2017.3.12. <http://www.scmp.com/tech/article/2078209/beijing-release-national-artificial-intelligence-development-plan>

[104] "China sets up national lab developing brain-like AI technology," Xinhuanet, 2017.5.14. <http://news.xinhuanet.com/english/2017-05/14/c_136282675.htm>

[105] 「Tech for Social Good 科技向善 ｜ T 项目发布」2018. 1. 10. 腾讯研究院 <https://mp.weixin.qq.com/s/7fYPb6394zC4GHN9ILA51Q>

[106] The 2017 Global Festival for A.Ideas Website <http://aideas.toutiao.com/index.html>

1. Influence of technological innovation

Since the advent of industrial society brought about by the Industrial Revolution, which took place in the UK, technological innovations have been constantly seen in the industrial arena. Technological innovations can sometimes lead to the elimination of jobs, but the influence of unemployment can be curbed if the number of jobs created by new technologies exceeds the number of jobs lost and labor movement is achieved. Indeed, during the Industrial Revolution, the number of jobs for craft workers in the textile industry decreased dramatically, but the heavy demand for workers in factories absorbed the loss (reallocation of human resources among industries and among businesses). On the other hand, if we look at post-war Japanese companies, they have maintained the long-term employment of regular employees (so-called permanent employment), which is considered an employment system unique to Japan, by addressing the needs for new skills brought about by technological innovations with personnel-related measures, such as job training and reallocation within the company.

Thus, the influence of technological innovations on employment is substantially affected by the liquidity of the labor market in each country (easiness of labor movement) and the employment system of each company (personnel system). Among them, the Japanese-style employment system has high adaptability to external environment changes, including technological innovation, and its structure did not easily lead to unemployment.

2. Influence of advanced technologies, including AI

In general, technological innovation affects the streamlining of tasks, but if it progresses further, jobs will be replaced by machines. This applies to today's advanced technologies, including AI. For example, tasks in which it is clear what is right can easily be replaced by AI, as long as we can input an abundance of "right data" because AI can perform the tasks more efficiently.[107] The tasks that Japanese white-collar workers perform are considered highly likely to be replaced by AI. According to a study, nearly 100% of jobs centered around routine desk work can be replaced.[108]

If the tasks that people perform will be limited due to advancements in AI and the like, the ability to reallocate personnel within a company will be limited, and the Japanese-style employment system, mentioned above, will be difficult to maintain. As today's technological innovations, mainly AI, progress rapidly, skills are likely to become outdated instantly even if companies have their employees learn the skills through on-the-job training. Thus, businesses may decide not to invest in such training, which will raise a question of who will perform human resources development.[109]

3. Influence of the advancement of information and communication technology

Owing to the advancement of information and communication technology (ICT), an environment where people can work anywhere by accessing information at any time and from anywhere is becoming a

[107] Noriyuki Yanagawa, et al., "Advantages of humans and management in the era of AI," *NIRA Opinion Paper*, No.25, 2016.11, pp.5-6. <http://www.nira.or.jp/pdf/opinion25.pdf>. (in Japanese)
[108] Tomota Terada et al., *Who supports the labor force in Japan?* Toyo Keizai, Inc., 2017, Appendix pp.2-18. (in Japanese)
[109] Shinya Ouchi, Work style and law: Looking into the labor law in 2035, Koubundou, 2017, pp.105-108. (in Japanese)

reality. This style of work will lower the need to go to the office and allow for telework (e.g., working at home, mobile work).[110] People will be able to run a business using information devices, such as smartphones, without having a special means of production, which will lower the hurdles to working without being employed and starting a new business.[111]

These phenomena are already spreading overseas. For example, in Europe, a fact-finding survey revealed that there are diverse new forms of employment, as shown in Table 1.

Table 1. New forms of employment in Europe

Forms of employment	Description
Employee sharing	Sharing of employees among multiple employers
Job sharing	Sharing of one post among multiple employees
Voucher-based work	To pay part of the salary with vouchers purchased from the government and the like
Interim management	Workers with specialized skills are hired for a fixed period and engage in a certain project
Casual work	Companies summon people and hire them when necessary
ICT-based mobile work	Teleworker
Crowd employment	Self-employment type of work using crowd sourcing
Portfolio work	Self-employed people provide services to multiple clients
Collaborative employment	Self-employed people provide services in collaboration with each other

(Source) Created by the author based on Eurofound, *New forms of employment*, Luxembourg: Publications Office of the European Union, 2015. <https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef1461en.pdf>.

4. Necessity of new legal rules

Japanese companies have emphasized employing regular employees; thus, they have not been active in the use of new technologies or new forms of employment. As discussed above, however, the Japanese-style employment system characterized by stable employment of regular employees and cultivation of human resources is now becoming difficult to maintain in the face of rapid technological innovations. Now, Japanese companies are required to use various human resources in various ways. Perhaps because of this background, the government has called for diversification of work styles and has encouraged businesses to reconsider prior work practices.[112]

Especially when new technologies, such as AI, replace human tasks, people who can generate added value by using their intellectual creativity, which cannot be done by machines, are desired. However, these people would probably prefer independent work styles, instead of being hired by companies and bound by labor regulations (e.g., work hour regulations).[113] What is now attracting attention from this perspective

[110] According to a survey conducted by the Ministry of Internal Affairs and Communications, 16.6% of companies have already adopted or are planning to adopt telework (2016). Ministry of Internal Affairs and Communications, "Results of the 2016 Communications Usage Trend Survey (Summary)," 2017.6.8, p.16. <http://www.soumu.go.jp/main_content/000489195.pdf>. (in Japanese)

[111] These visions are summarized in "Future of Work: 2035: For Everyone to Shine" Panel "Future of Work: 2035: For Everyone to Shine," 2016.8. Ministry of Health, Labour and Welfare Website <http://www.mhlw.go.jp/file/05-Shingikai-12601000-Seisakutoukatsukan-Sanjikanshitsu_Shakaihoshoutantou/0000132302.pdf>. (in Japanese)

[112] Referenced websites include "Action Plan for the Realization of Work Style Reform" (Decided at the meeting of the Council for the Realization of Work Style Reform on March 28, 2017) Office of Prime Minister Website <https://www.kantei.go.jp/jp/headline/pdf/20170328/01.pdf>. (in Japanese)

[113] Ouchi, *op.cit.* (109), pp.144-145.

is a self-employment type of work style (not employed). Indeed, cases of asking crowd workers, who are individual self-employed workers, to do tasks (crowd sourcing) are also increasing in Japan.[114]

Thus far, self-employed workers have been less protected than unemployed workers. They are not covered by labor law, and they are not covered by employment insurance or workers' accident compensation insurance in terms of social security. In addition, they cannot enroll in employee pension or health insurance programs, where business owners need to pay part of the insurance premiums. People in Europe see that some sort of legal intervention is necessary for the self-employment type of work style at least if it involves an economic dependence, and they have begun discussing whether the protection of workers should be extended to self-employed workers and whether an intermediate legal status between workers and self-employed workers should be acknowledged.[115]

Shinya Ouchi, Kobe University

VI Human Resources and Labor Management by ICT and Its Regulation: Japan and Overseas

1. Introduction

Even before the spread of ICT, employee monitoring was done via supervisor's through visual judgments, daily reports, and the like in order to facilitate the smooth and proper implementation of tasks and maintain corporate order. In labor using ICT, ICT is a tool for labor, but at the same time it can also be a tool for monitoring and record keeping. Such data are used to understand the attendance and working situation of employees for labor control purposes, such as motivation and productivity enhancement, and the results of analyzing such data are also used for personnel evaluation. In this section, we will discuss the use of ICT in employee monitoring and personnel evaluation and the related issues and legal regulations.

2. Use of ICT in employee management and personnel management

According to the Institute of Labor Administration, Japan, 57.7% of surveyed Japanese companies said that they monitor employees' internet connection status, sent and received emails, and operations of devices that they provide to their employees.[116] They can thoroughly monitor and keep records of the activities of employees working away from their office through smartphones and special wearable devices. A Canadian company, Vandrico Solutions, which supplies software for management of workers equipped with wearable devices, sells a system equipped with GPS and integrated with wearable devices that

[114] Ministry of Internal Affairs and Communications (ed.), *2015 White Paper on Information and Communications*, 2015, pp.215-216. <http://www.soumu.go.jp/johotsusintokei/whitepaper/ja/h27/pdf/n4300000.pdf>.

[115] Alain Supiot, *Au-delà de l'emploi*, Nouvelle Édition, Paris: Flammarion, 2016, pp.45-83. Similar discussions are also being held in Japan. "Committee for investigating work forms similar to employment" Ministry of Health, Labour and Welfare Website <http://www.mhlw.go.jp/stf/shingi/other-kintou.html?tid=488802>; Study group of "employment-free work styles," "Report of the study group of 'employment-free work styles'," 2017.3. Ministry of Economy, Trade and Industry Website <http://www.meti.go.jp/report/whitepaper/data/pdf/20170330001-2.pdf>.

[116] Institute of Labour Administration, "Survey of the use of IT devices at work," 2017.8.31, p.3. <https://www.rosei.or.jp/research/pdf/000071316.pdf>. (in Japanese).

monitors the locations and health conditions of employees engaging in dangerous tasks in mineral mines and the like.[117] In addition, dynamic management and dispatching of taxis, sales vehicles, and company cars using GPS are now widely used. A sales assist system is also sold for managing the locations of employees engaging in sales activities using GPS information from their smartphones.

ICT used in the field of personnel management is called "HR Tech (Human Resources Technology)." HR Tech may range from a personnel management tool for coordinating hiring schedules and managing attendance and background information to services and software for analyzing and evaluating personnel records, including attendance management and performance evaluation, supposedly using deep learning and automatically judging the most appropriate types of work or job positions.[118]

Several companies launched wearable devices and its applications which are intended to improve the quality of tasks performed by employees. For example, a system using wearable sensors has been suggested to record the activities of employees, predict interactions among employees and the activeness of the organization, and enhance employees' motivation.[119] There is also an eye-glass-type wearable device that can measure the degree of concentration of employees based on the number of times they blink to support work.[120]

3. Issues and problems

Employees are obligated to provide labor, concentrate on their duties, maintain corporate order, and respect employers' facility management rights through the employment contract between employee and employer. Therefore, employee monitoring can be legally and ethically justified. However, there is a court ruling that if monitoring and record keeping are comprehensive and detailed, then they will put strong psychological pressure on employees, and they should be an invasion of personal rights when there is no consent.[121] The obligation to concentrate on duties is an obligation to sincerely perform tasks based on a labor contract. However, actions that do not actually disturb the tasks allocated by the employer are not necessarily violation of the obligation to concentrate on duties, even during work hours.[122] This is because employees' private sphere, from their private life to their mind, should not be monitored and controlled by the employer.

On the other hand, personnel evaluations using AI, such as deep learning, can be problematic in terms of the biases in the judgments and the fair consideration of individual circumstances. Judgments by machines tend to be regarded as fair, and they can easily hide the biases of designers and operators[123]. By too rigorously following machine judgements, circumstances or elements that need to be considered

---

[117] Geof Wheelwright, "IoT-linked wearables will help workers stay safe," *Financial Times*, 2017.10.11.

[118] Shota Uehara, "With AI, no need for human resources division? Bizreach and Yahoo, optimal allocation using data," Nihon Keizai Shimbun, 2016.6.15, p.11; "Less recruitment tasks using IT, human resources-related companies support streamlining using cloud," Nihon Keizai Shimbun, 2017.8.24, p.14. (in Japanese).

[119] Kazuo Yano, Invisible hands of data: Laws of human, organization and society revealed by wearable sensors, Soshisha, 2014, pp.133-175. (in Japanese).

[120] 「JINS MEME ES」 JINS MEME Website <https://jins-meme.com/ja/products/es/>. (in Japanese).

[121] Decision of Tokushima District Court, November 17, 1986, Roudo Hanrei, No. 488, p.46. (in Japanese)

[122] Decision of the Third Petty Bench of the Supreme Court, April 13, 1982, Supporting opinion by Judge Masami Ito, Supreme Court Reports (criminal cases), Volume 36, No. 4, p.659. (in Japanese)

[123] Batya Friedman and Helen Nissenbaum, "Bias in Computer Systems," ACM Transactions on Information Systems, July 1996, pp.330-347.

individually may be ignored. AI's judgment is derived from correlations, not from cause-and-effect relationships. Therefore, when making personnel evaluations and personnel allocation by using AI, we cannot often present reasonable grounds for the judgment. However, legal issues pertaining to personnel evaluations using AI, including deep learning, have not come to the surface at this point, and no legal regulations have been established[124]. Therefore, we will discuss legal regulations on employee monitoring using ICT hereinafter.

4. Regulations on ICT monitoring of employees in Japan

The Personal Information Protection Commission (Kojin Joho Hogo Iinkai), an independent agency for Japanese government, which supervise and settling dispute over personal information, says that in terms of ICT monitoring of employees in general in relation to tasks involving the handling of personal data, there should be restrictions on the purpose and personnel authorized to perform monitoring, as well as advance notice to and discussions with labor unions, clear definitions in working regulations, and auditing.[125] In light of the intent of the "Act on the Protection of Personal Information" (Act No. 57 of 2003, "Kojin Joho no Hogo ni kansuru Horitsu, " hereinafter "Personal Information Protection Law (Kojin Joho Hogo Ho)"), this prescription applies not only to the monitoring of tasks involving the handling of personal data but also to the monitoring of other tasks.[126] In companies or other institutions, phone numbers, device identification numbers, and IP addresses of employees' smartphones can be easily cross-checked with other information to identify individuals. Therefore, they falls under the "individual identification codes" in Section 2, Article 2 of the Personal Information Protection Law.[127] Therefore, monitoring using the location information services of mobile devices or wearable devises should be treated the same as the monitoring of the above tasks.

We will introduce two of the key court decisions related to this issue, especially on the monitoring of employees' use of emails, although they are given before the Personal Information Protection Law was enacted and lower court decisions..

(1) Monitoring of the use of emails can be permitted in light of employers' facility management rights. Compared with the use of telephones, the scope of privacy protection in emails is significantly reduced. On the other hand, private emails can be permitted within the scope reasonably necessary if they do not interfere with duties and put only a little financial burden on the employer.[128]

(2) To decide whether monitoring of the use of emails is an invasion of employees' privacy, we consider the purpose of monitoring and the appropriateness of its method as well as other aspects (e.g., whether it is monitoring as a duty of a person authorized to supervise employees) in a comprehensive manner.[129]

---

[124] Daniel Keats Citron and Frank A. Pasquale, "The Scored Society: Due Process for Automated Predictions," *Washington Law Review*, Vol. 89, 2014, pp. 1-34; Frank A. Pasquale. The Black Box Society, Harvard University Press, 2015.

[125] Personal Information Protection Commission, "Q & A about "Guidelines on the law pertaining to the protection of personal information)" and "About responses in the event of personal data breach," 2017.2.16 (updated on 2017.5.3), p.23 <https://www.ppc.go.jp/files/pdf/kojouhouQA.pdf>. See the section "Supervising of employees" (Q4-6). (in Japanese)

[126] Same as above, pp.4-5. See the section "Personal information" (Q1-17). (in Japanese)

[127] Same as above, p.6. See the section "Personal identification code" (Q1-22). (in Japanese)

[128] Decision of Tokyo District Court, December 3, 2001, Roudo Hanrei, No. 826, p.76. (in Japanese).

[129] Same as above; Decision of Tokyo District Court, February 26, 2002, Roudo Hanrei, No. 825, p.50 (in Japanese).

Similarly, another lower court decision states that monitoring of employees using the location information function of smartphones is illegal except "during working hours when employees are obligated to provide labor," also before the Personal Information Protection Law was enacted.[130]

5. Regulations on ICT monitoring of employees overseas

(1) United States of America

The US has federal laws called "Electronic Communications Privacy Act of 1986 (ECPA)"[131] and "Stored Communications Act (SCA),"[132] which is a part of ECPA. These laws control interceptions of communications in general and do not directly regulate monitoring of employees' communications. Employers must notify employees in advance to monitor their emails in the states of Connecticut and Delaware.[133]According to court rulings, monitoring of emails and web browsing at work is permitted without prior notification to employees when there is due cause, in light of the employers' facility management rights, except in these two states. However, it is illegal to view and save information on employees' private accounts stored on servers owned by a third party outside the workplace without employees' consent.[134]

In addition to these, as state law-based regulations, it is considered illegal in several states (e.g., California, Illinois) for employers to request disclosure of user IDs and passwords that employees use on social media. States such as Missouri and North Dakota have a state law explicitly prohibiting monitoring by implanting radio frequency identification (RFID) tags in employees' bodies.

(2) Canada

The Personal Information Protection and Electronic Documents Act (S.C.2000, c.5) in Canada applies only to federally regulated companies (e.g., airlines, financial institutions). Yet, there is a judgement of the Supreme Court of Canada that employers' monitoring of web browsing is illegal because employees' browsing history contains secrets of the mind when computers at work are allowed or because it is rationally expected to be used for private purposes.[135]

(3) EU

The Article 88 of the General Data Protection Regulation (GDPR),[136] which was applied in May 2018, says to "include suitable and specific measures to safeguard the data subject's human dignity,

---

130 Decision of Tokyo District Court, May 31, 2012, Roudo Hanrei, No. 1056, p.19. (in Japanese).

131 Electronic Communications Privacy Act of 1986 (P.L. 99-508)

132 Stored Communication Act (18 USC §§2701-12). This was enacted as part of ECPA (Title II).

133 Brenda R. Sharton and Karen L. Neuman, "The Legal Risks of Monitoring Employees Online," *Harvard Business Review*, 2017.12.4. <https://hbr.org/2017/12/the-legal-risks-of-monitoring-employees-online>.

134 V. John Ella, "Employee Monitoring and Workplace Privacy Law," National Symposium on Technology in Labor & Employment Law, Washington, D.C., April 6,7 and 8, 2016, p.8. <https://www.americanbar.org/content/dam/aba/events/labor_law/2016/04/tech/papers/monitoring_ella.authcheckdam.pdf>.

135 R. v. Cole, 2012 SCC 53, 2012.10.19. Supreme Court Judgments Website <https://scc-csc.lexum.com/scc-csc/scc-csc/en/item/12615/index.do>.

136 "REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 20 16 on the protection of natural persons with regard to the processing of personal data and on the free movement o f such data, and repealing Directive 95/46/EC (General Data Protection Regulation)," Official Journal of the Europea

legitimate interests and fundamental rights, with particular regard to the transparency of processing, the transfer of personal data within a group of undertakings, or a group of enterprises engaged in a joint economic activity and monitoring systems at the work place." The GDPR also requires clear "consent" of the data subject when collecting personal data (Article 4 (11) and imposes a severe fine in the event of a violation (Article 83). Thus, in EU countries, employers will be required to adopt the principle of obtaining consent when monitoring employers. Adding to that, according to the survey conducted by an NPO that provides legal information to employees, the consent of employees alone is insufficient because the employer-employee power balance is asymmetrical, a Belgian employment and labor lawyer pointed out.[137]

In September 2017, the European Court of Human Rights gave a ruling that companies must give prior notice to employees when they are going to monitor employees' email accounts.[138]

Takushi Otani, Kibi International University

VII Development and Recruitment of AI-related Human Resources

1. Current situation surrounding AI-related human resources

(1) Japan

Along with the increase in computing abilities and speed and advancements in cloud and storage technologies, new products and services are being created one after another. The use of big data, IoT, and AI is expected to become increasingly more sophisticated and diversified in the future. As these changes occur, the inability to supply sufficient IT-ready human resources who have advanced skills in IT has become a problem.

The number of IT human resources (human resources belonging to IT vendors, web-related businesses, or the information system department of IT user companies) is expected to take a downward turn in 2019. The aging of such human resources is also expected,[139] which suggests that it is highly likely that the shortage of human resources will become more serious. In particular, there was a shortage of about 15,000 people in terms of advanced IT human resources (those engaging in big data, IoT, and AI) in 2016, and it is estimated that there will be a shortage of about 32,000 people in 2018 and 48,000 people in 2020 (Figure 1).

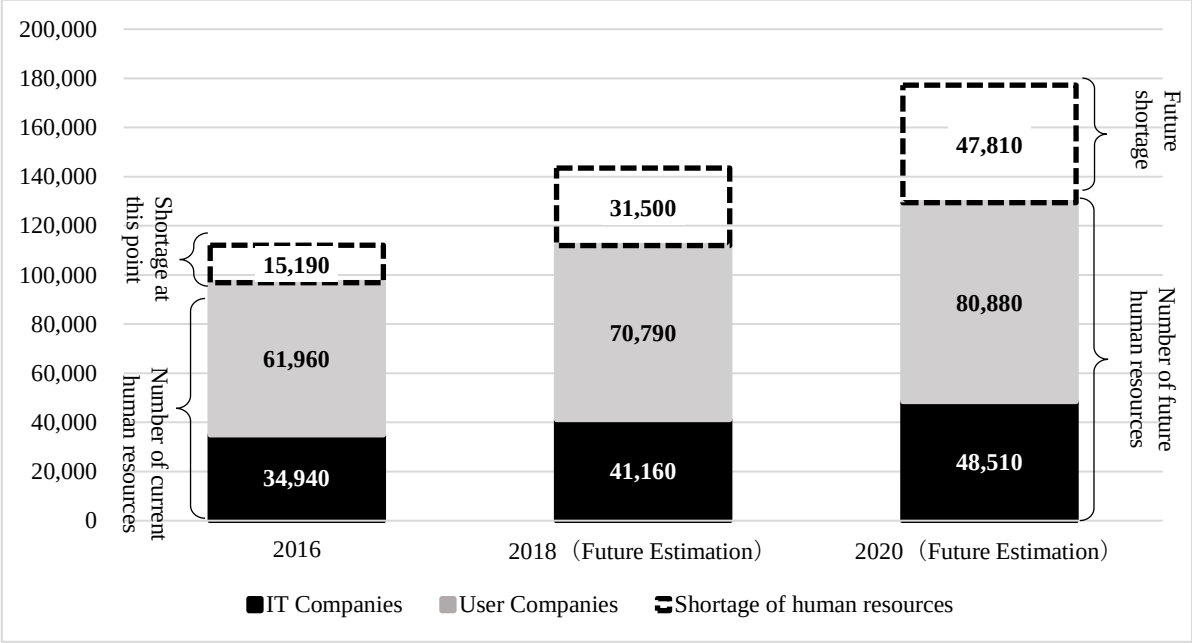
n Union, L119, 2016.5.4, pp.1-88. <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN>.

[137] Employment Law Alliance, "Employee Data Privacy in Europe: The Essentials for Multinational Employers," 2016, p.12. <http://www.employmentlawalliance.com/Templates/media/files/Misc%20Documents/EU-Data-Privacy2016.pdf>.

[138] *Judgment: Case of Bărbulescu v. Romania*, European Court of Human Rights, 2017.9.5. <http://hudoc.echr.coe.int/eng?i=001-177082>.

[139] Mizuho Information and Research Institute, "Model project for cultivating and securing human resources to promote innovation by IT ventures, etc. Project Report Part 2: Building an estimation model of future demand and supply of IT human resources," 2016.3, pp.30-31. Ministry of Economy, Trade and Industry Website <http://www.meti.go.jp/policy/it_policy/jinzai/27FY/ITjinzai_fullreport.pdf>. (in Japanese).

Figure 1. Shortage of advanced IT human resources and future estimations



(Note) The shortage figure in 2016 was estimated based on web-based questionnaire surveys and hearing surveys, and the shortage figures in 2018 and 2020 are differences between the future human resources demand estimated based on the market growth rate and web-based questionnaire surveys and the future human resources supply estimated based on demographics, the hiring rate, and the turnover rate.

(Source) Created based on Mizuho Information and Research Institute, "Model project for cultivating and securing human resources to promote innovation by IT ventures, etc. Project Report Part 2: Building an estimation model of future demand and supply of IT human resources," 2016.3, p.218. Ministry of Economy, Trade and Industry Website <http://www.meti.go.jp/policy/it_policy/jinzai/27FY/ITjinzai_fullreport.pdf> (in Japanese)

(2) Overseas

There is also a shortage of advanced IT human resources overseas. In the US, AI-related offers are drastically increasing. Of them, 40% are from leading IT companies such as Amazon, Google, Microsoft, IBM, and the Chinese company Huawei.[140] These IT companies and manufacturing businesses such as General Electric (GE), Samsung, and Ford are acquiring venture companies that have AI technology. There is also fierce international competition over AI human resources. For instance, an eminent AI researcher at Google began working for the Recruit Institute of Technology in Japan,[141] while Google announced that the company would begin hiring AI human resources in China.[142] Leading IT companies in China, such as Baidu, Tencent, and Alibaba, are also recruiting top-level AI human resources in Silicon Valley in the US. Moreover, the level of wages for AI human resources is skyrocketing in the US. Wages offered to AI engineers (about 15 million yen) are more than double the wages offered to AI human resources in Japan (about 6.5 million yen).[143]

[140] Stacy Jones, "Automation Jobs Will Put 10,000 Humans to Work, Study Says," *Fortune*, 2107.5.1. <http://fortune.com/2017/05/01/automation-jobs-will-put-10000-humans-to-work-study-says/>.

[141] "Recruit hunts the brain of Google," Nihon Keizai Shimbun, 2017.6.16, p.1. (in Japanese).

[142] "US Google, hiring AI human resources in China to complement task in US," Nihon Keizai Shimbun, 2017.5.25, p.15. (in Japanese).

[143] Information-technology Promotion Agency, White Paper on AI Editorial Committee (ed.), *White Paper on AI 2017: Technological innovation and social changes brought by artificial intelligence*, Kadokawa Ascii Research Laboratories, 2017, p.215. (in Japanese).

The AI industry is also active in hiring people from academia. For example, there are many people with skills related to machine learning technologies and with astrophysics backgrounds at an American machine learning venture called Wise.io.[144] Uber Technologies, an American company providing dispatch services, hired researchers who used to work at the National Robotics Engineering Center (NREC) for its autonomous vehicle research division.[145] Because of these outflows of researchers to the industrial world, there are concerns regarding a shortage of human resources who can promote research and engage in education.[146]

2. Skills required of AI-related human resources

Because people can now obtain much more data (big data) than they were able to in the past, researchers today in the area of AI mainly study "machine learning," which obtains knowledge from big data, and "deep learning," which extracts feature quantities. However, in addition to intelligent informatics, which deals with machine learning and the like, there are various relevant research fields, such as computer science (e.g., algorithm, network), robotics, ontology,[147] cognitive science, and neuroscience.

On the other hand, to use AI in business, abilities to sort out and solve issues are also necessary. The Information-technology Promotion Agency (IPA) has presented the skills required of IT human resources as skill standards for IT professionals "ITSS+." These standards show that skills in "business," "data engineering," and "data science" are necessary in the field of data science where people create value from data using machine learning and deep learning (Table 2). In addition to skills, concrete tasks are also addressed in the skill standards for IT professionals "ITSS+."[148]

Table 2. Skills required in the field of data science

Skill category	Description
Business	Sorting out and solving business issues after understanding the background of the issues
Data science	Understanding and utilizing knowledge of information science, such as information processing, AI, and statistics.
Data engineering	Making data science useful and meaningful to implement and operate it.

(Source) "ITSS+ Data science domain, skill domain, and skill category" (updated on February 1, 2018) Information-technology Promotion Agency Website <https://www.ipa.go.jp/files/000063897.xlsx> (in Japanese)

3. Cultivation and recruitment of AI-related human resources in Japan

As AI businesses are expected to grow, companies in Japan are becoming active in cultivating human resources and hiring new people. For instance, Fujitsu and NEC reeducated their system engineers as AI human resources. Fujitsu is looking to increase its current number of AI human resources by 3.5 times by

[144] Wise.io was acquired by GE in 2016. Cade Metz, "Giant Corporations Are Hoarding the World's AI Talent," *WIRED*, 2017.1.3. <https://www.wired.com/2016/11/giant-corporations-hoarding-worlds-ai-talent/>.

[145] Anne Steel, "Carnegie Mellon Reels After Uber Lures Away Researchers," *Wall Street Journal*, 2015.6.1. < http://jp.wsj.com/articles/SB12759595096617873597504581020681775312842>.

[146] Lauren Dixon, "How Brain Drain from Academia Could Impact the AI Talent Pool," January 11, 2017. Talent Economy Website <http://www.talenteconomy.io/2017/01/11/brain-drain-academia-impact-ai-talent-pool/>.

[147] Ontology refers to vocabulary or the basic concept for describing knowledge or the structural relationship for knowledge processing of expert systems and the like.

[148] "ITSS+ Data science domain, task" (updated on February 1, 2018), Information-technology Promotion Agency Website <https://www.ipa.go.jp/files/000063897.xlsx>. (in Japanese)

the end of fiscal 2018, while NEC is looking to increase its number of such resources to over 1,000 by 2020.[149] To secure AI human resources that are running short, companies such as Sony, Toyota Motor Corporation, and Hitachi are working on hiring new people not just in Japan but also overseas.[150] On one hand, there are concerns regarding the overflow of domestic AI human resources to overseas companies that have abundant budgets.

There are many systems and courses that help working people and students acquire the appropriate skills. In 2017, the Ministry of Economy, Trade and Industry launched the "System for certifying skill acquisition courses for the fourth industrial revolution," which certifies education and training courses for working people in the areas expected to grow in the future, such as AI, IoT, data science, and cloud computing.[151] In addition, in 2017, the Ministry of Education, Culture, Sports, Science and Technology began the "Data-related human resources development program" to promote the cultivation of human resources who use data-related technologies (e.g., AI, IoT big data, security), targeting students in doctoral courses and those with doctoral degrees.[152]

In terms of universities, Shiga University newly established the Faculty of Data Science in 2017, and Yokohama City University, Hiroshima University, and Kyoto Sangyo University have announced that they will to newly establish a data science-related faculty (course) in 2018.[153] Academia-industry efforts include the Chair for Frontier AI Education of the University of Tokyo (donated by 8 companies) and an AI course jointly provided by Osaka University and Panasonic to cultivate human resources.[154] There are also a variety of efforts in the private sector, such as seminar-type courses provided by ALBERT and BrainPad,[155] a course provided through online movies on the online learning platform called Udemy,[156] and a machine learning study group[157] held by TeamAI, a community for AI engineers.

As future issues related to the cultivation of AI human resources, awareness toward the risks of AI and motivation for the use of AI must be heightened. Compared with other countries, motivation for AI human resources development is low in Japan. According to a questionnaire survey, only 19.4% of companies in Japan are cooperating with external organizations, such as universities and external institutions, to cultivate their own human resources, which is less than half of the share, 41.1%, in the US (Figure 2). According to a survey that asked respondents what kind of AI skills they want to acquire or

---

149 "Fujitsu and NEC find talent among SE, reeducating their own IT people for cyber defense and AI reinforcement," *Nihon Keizai Shimbun*, 2017.8.14, p.5. (in Japanese)

150 Information-technology Promotion Agency, White Paper on AI Editorial Committee (ed.), *op.cit.* (143). (in Japanese)

151 Ministry of Economy, Trade and Industry, "METI to Establish a New Program for Certifying Courses on IT-Skill Training to Meet the Era of the Fourth Industrial Revolution" 2017.8.7. <http://www.meti.go.jp/english/press/2017/0807_002.html>

152 Ministry of Education, Culture, Sports, Science and Technology, "Doctoral program for Data-Related InnoVation Expert(D-DRIVE) Data-related human resources development program," 2017.4. <http://www.mext.go.jp/a_menu/jinzai/data/index.htm>. (in Japanese)

153 Yokohama City Policy Bureau, "About the establishment of the faculty of data science at Yokohama City University," 2017.5.29. < http://www.city.yokohama.lg.jp/shikai/pdf/siryo/j1-20170529-ss-11.pdf> (in Japanese); Hiroshima University, "Establishing "<Faculty of Information Sciences> and <Department of Integrated Global Studies> in 2018," 2017.8. <https://www.hiroshima-u.ac.jp/news/38756> (in Japanese); Kyoto Sangyo University, "Faculty of Information Science and Engineering is coming!!" 2017.7.11. <https://www.kyoto-su.ac.jp/news/20170711_195_ise.html>.

154 University of Tokyo, "University of Tokyo establishes Chair for Frontier AI Education," 2016.5.30. <http://www.isi.imi.i.u-tokyo.ac.jp/pdf/IST_Press>; Osaka University, Osaka University and Panasonic to Begin Joint Collaborative Course in Artificial Intelligence," 2016.6.22. < http://www.osaka-u.ac.jp/en/news/topics/2016/06/20160622_01>.

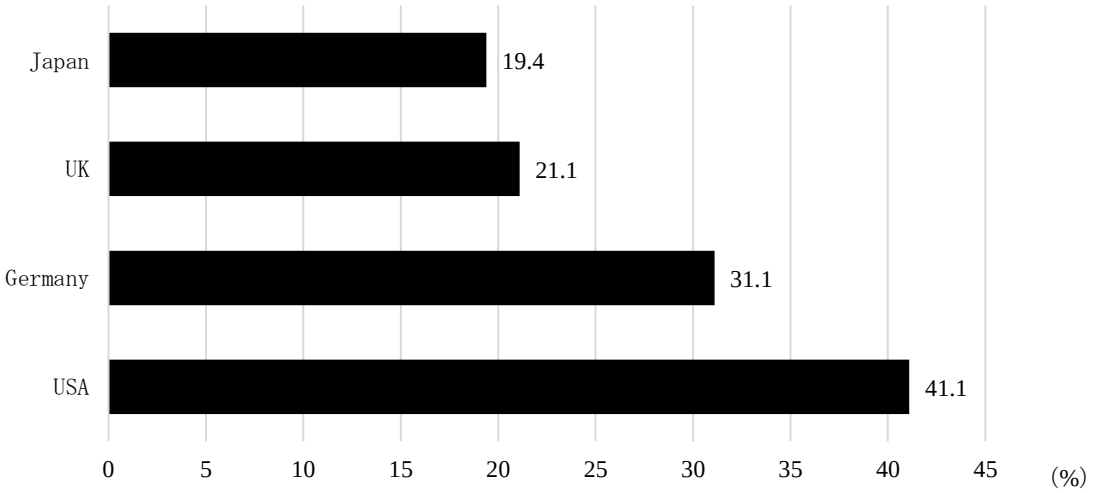
155 "Data Scientist Training Course" ALBERT Website <https://www.albert2005.co.jp/DST/> (in Japanese); "BrainPad Education Course" BrainPad Website <http://school.brainpad.co.jp/> (in Japanese).

156 "Data Scientist Training Course" Udemy Website <http://www.benesse.co.jp/udemy/datascientist/> (in Japanese).

157 TeamAI Website <https://www.team-ai.com/> (in Japanese).

have their children acquire, people in Japan were less motivated to acquire technological competence for using AI, programming skills, implementation skills, creativity, design competence, and engineering capabilities than people in the US. Thus, there is a concern that Japan will miss out on the global wave of the introduction and use of AI and that the gap between Japan and the US will widen, from the perspective of human resources development.[158]

Figure 2. Share of companies cooperating with external organizations to cultivate their employees



(Note) The shares of the UK, Germany, and the US are calculated based on web-based questionnaire surveys conducted with people at the management level, not questionnaire surveys conducted with individual companies.

(Source) Created by the author based on Information-technology Promotion Agency, White Paper on AI Editorial Committee (ed.), *White Paper on AI 2017: Technological innovation and social changes brought by artificial intelligence*, Kadokawa Ascii Research Laboratories, 2017, p.220, 343-344. (in Japanese)

Etsuko Tane, The University of Tokyo

[158] Ministry of Internal Affairs and Communications (ed.), *2016 White Paper on Information and Communications*, 2017, p.258. <http://www.soumu.go.jp/johotsusintokei/whitepaper/ja/h28/pdf/n4400000.pdf> (in Japanese).

List of Authors

Arisa Ema (chair), The University of Tokyo
Hiromitsu Hattori (chair), Ritsumeikan University

Part 1

Ryutaro Ichise, National Institute of Informatics
Mamoru Komachi, Tokyo Metropolitan University
Atsushi Nakazawa, Kyoto University
Kazunori Komatani, Osaka University
Tomoko Yonezawa, Kansai University
Itsuki Noda, National Institute of Advanced Industrial Science and Technology
Yutaka Arakawa, Nara Institute of Science and Technology
Hiromitsu Hattori (chair), Ritsumeikan University
Yukino Baba, Kyoto University

Part 2

Takanori Fujita, National Center for Global Health and Medicine
Naonori Akiya, Yamaguchi University
Reina Saijo, Kyoto University
Hideaki Iwahori, The University of Tokyo
Hirotaka Osawa, University of Tsukuba
Arisa Ema (chair), The University of Tokyo
Takashi Seto, Asia Pacific Initiative
Akinori Kubo, Hitotsubashi University

Part 3

Fumiko Kudo, Makaira KK
Naoko Abe, Ecole des Hautes Etudes en Sciences Sociales
Danit Gal, Keio University
Shinya Ouchi, Kobe University
Takushi Otani, Kibi International University
Etsuko Tane, The University of Tokyo

Translation from Japanese language edition
Perspectives on Artificial Intelligence/ Robotics and Work/Employment

Permalink: http://hdl.handle.net/10367/11072

English translation licensed by AIR (http://sig-air.org/)
July 17th, 2018
Edited by Arisa Ema & Hiromitsu Hattori
E-mail: contact@sig-air.org
AIR takes full responsibility for the translation of the report