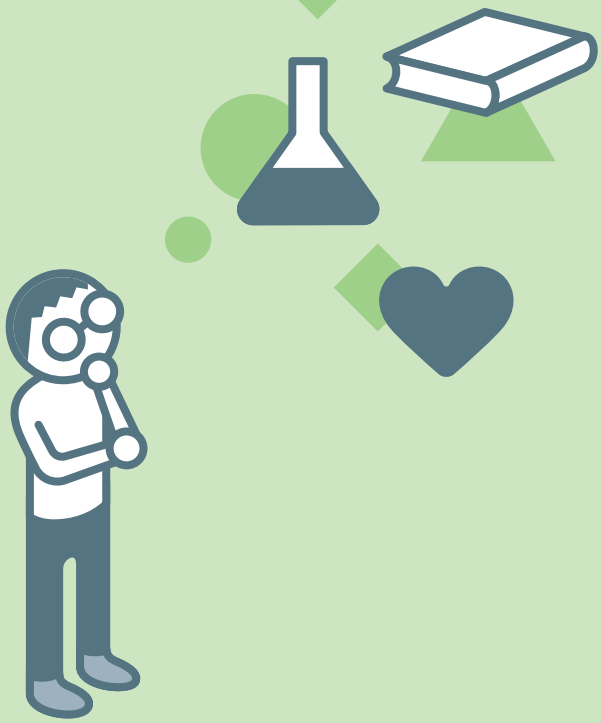
Part 2

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.

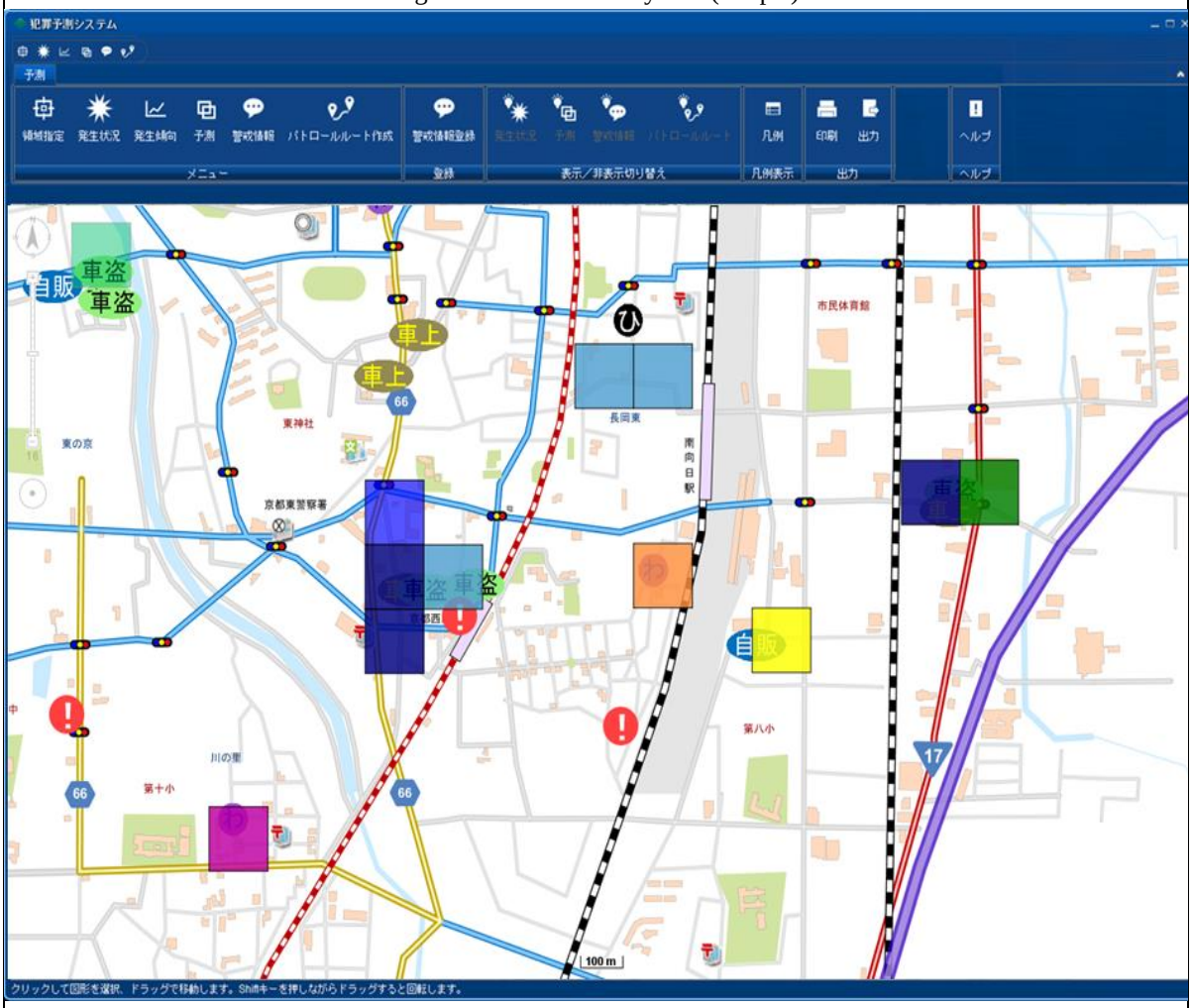
Data and infrastructure are necessary to build a system. Although police organizations in Japan cannot use external cloud services, in about 2004, the Kyoto Prefectural Police Department began accumulating crime data, established infrastructure for a unique geoinformation system (GIS), built a secure 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

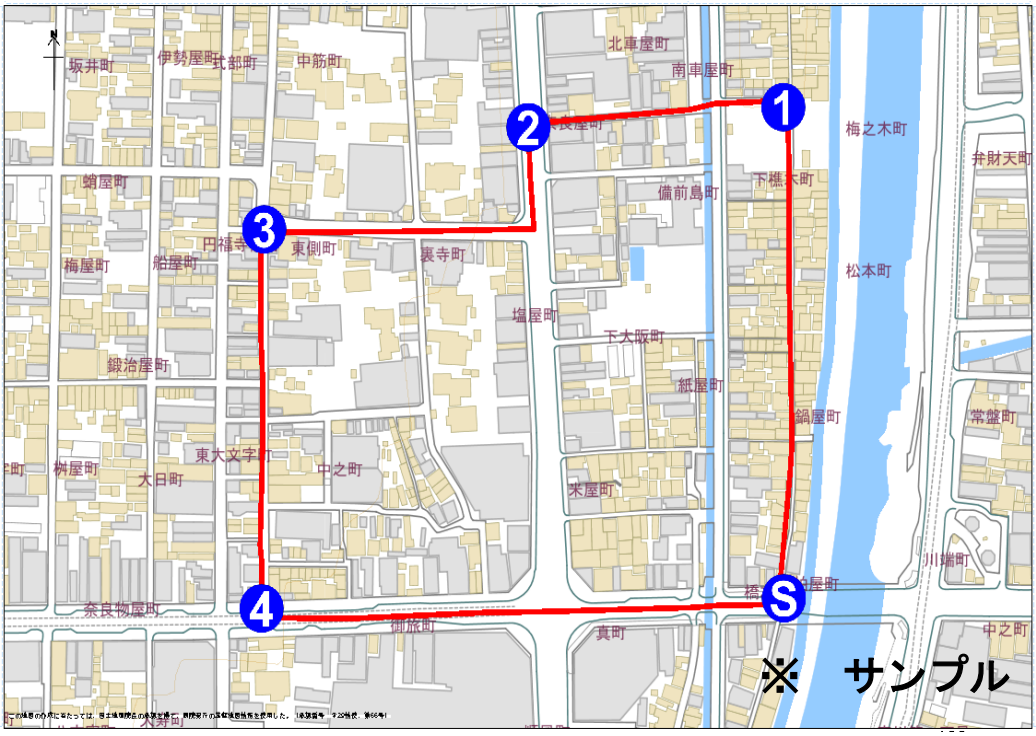
Police officers can access the System from their PCs at the headquarters and *Koban* (police station) through the secure network. The System is used when each police officer determines where to patrol or where to monitor, which contributes to efficient patrols. It also plays a supporting role so that 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)