Kindai Management Review Vol. 5, 2017 (ISSN: 2186-6961)

The Human-AI Ecosystem: A Nonhuman-Centric Approach

Jiro Kokuryo

Keio University, Japan

Akiko Kaya

Japan Science and Technology Agency, Japan

Abstract

Businesses are briskly and speculatively investing in research of ethical, legal and social issues surrounding artificial intelligence to ensure adequate governance of the technology. AI seems more than just another technology as its superior intellectual capabilities have put into question the supremacy of humanity over machines. It also casts questions on the autonomy of minds as the sole possession of human beings. Indications of diverse attitudes toward such fundamental issues across cultures exist. For example, the Japanese, due to their animistic background, would be more accommodating to the idea of AI as a mindful being. Adoption of this idea leads to a design philosophy for artificial intelligence free from the exclusively human-centric viewpoint. A cross-cultural research agenda based on this assumption is proposed for verification.

Keywords: *Artificial Intelligence, technology and society, ELSI, Business ethics, IT*

IS INFORMATION TECHNOLOGY ENTERING A FORBIDDEN TERRITORY?

Consideration of human-technology interaction, and particularly of ethical, legal and social issues (ELSI) is becoming critically important for businesses that would like to take advantage of advanced information technologies. As an example, when we allow artificial intelligence (AI) to drive automobiles on our behalf, we should anticipate a situation in which AI has to sacrifice a human life in order to save another. How should automobile companies design the "brain" that drives these cars, given that the cost of misjudgment could be daunting.

One area in which this issue will become critical for business at large is that of regulatory policies on AI. On December 31, 2016, the Japan Economic Journal reported official intentions to make product certification compliant with ethical codes. It also reported plans to limit the liability of users of AI products in cases of damages caused by "runaway artificial intelligence". While there has been no official confirmation of these plans, the article reflects expectations by industry that some form of regulatory action is being considered. Whatever its eventual shape, regulation will greatly impact technological development though at this point distinct principles for governance have not yet emerged.

Traditionally, businesses have tended to regard ethical, legal and social issues (ELSI) as a deterrent to the development of new opportunities. But it is increasingly becoming evident that the capacity of society for constructive discussion of ELSI and its ability to swiftly provide governing structures for emerging technologies will be seen as an advantage in the use of technology and therefore become

crucial for its development. No doubt, commodities shipped in compliance with solid "codes" of AI product development will reap considerable market benefits.

A global agreement on AI governance principles, however, may be harder to achieve than expected. Cultural differences play a significant role here. While there are relatively simple issues such as ensuring that robots do not harm humans physically, there can be others that touch upon delicate issues showing up diversity among cultures. Of particular interest in this paper is whether to consider humans as the "masters" of the world, as western cultures tend to perceive them, or simply as players—among others—as some eastern cultures do. The difference would be reflected in the degree of "autonomy" that humans would like to allow AI to assume. Is there a point where AI can override human decisions in the face of perceived danger?

The reason why mastership and autonomy of AI become issues is due to the prediction that its capability may come to surpass that of humans. The notion has been around in novels or movies for quite some time. Illustrations of how AI that acquires a mind and emotions of its own can rebel against human judgment appeared in 1967 in "2001: A Space Odyssey". More recently Kurzweil (2005) made the prediction that a "singularity" would occur by 2045 when the cognitive capability of AI is thought to surpass that of humans. Kurzweil's prediction is seemingly becoming real with events such as the victory of "deep learning" machines beating the world champion in the game of Go and the rapid development of autonomous driving which, in turn, has prompted policy makers to consider such issues as copyright of music generated by machines, and the legal and moral responsibilities for accidents caused by the misjudgment of autonomous cars.

Less philosophical, but perhaps more alarming to some is the job implications of AI. Fear of technology destroying employment has been around since the days of the Luddite movement. The fear has been renewed in recent research at Oxford University which estimated (Frey and Osborne, 2013) that 47% of total US employment was at risk of being replaced by AI and robots.

Most prominent among recent threats stemming from technology are perhaps those posed by nuclear technology and advances in genetics. Nuclear technology gave human beings the power to destroy themselves (Nye, 1988), while progress in the life sciences, especially genetics, gave us the power to manipulate life, which had long been considered an act only within God's power. As it stands, these technologies remain controversial and far from being governed in anything more than contradictory terms.

Today's information technologies seem to violate God's territory as well, both in terms of their power and their deep invasion of our minds. If self and existence are defined by the act of thinking, as the French philosopher Descartes wrote in 1637 in his historic "Discourse on the Method," "I think, therefore I am," then thinking machines should be considered to have a life of their own.

INITIATIVES IN ELSI STUDIES SURROUNDING IT

With growing awareness of the potential impact of information technology on the fundamental nature of human life and society, research institutions around the world are starting to pay serious attention to ELSI in relation to information technologies.

Of particular relevance to the readers of this journal would be the extent to which private businesses are exhibiting intentions of investing in ELSI research. A notable example is the Future of Life Institute at the Massachusetts Institute of Technology, which has received a large donation from an entrepreneur with interests in the advancement of AI technology in a way that does not compromise its benefits. More recently, a symbolic move by the industry that shows its seriousness in the matter came on September 28, 2016, when Amazon, DeepMind/Google, Facebook, IBM, and Microsoft announced the formation of a "Partnership on Artificial Intelligence to Benefit People and Society." Its purpose is to "study and formulate best practices on AI technologies, to advance the public's understanding of AI, and to serve as an open platform for discussion and engagement about AI and its influences on people and society" (http://www.partnershiponai.org/ last accessed

Oct. 2, 2016). While we are yet to see outcomes from this initiative, it shows that industry is considering ELSI as a critical part of its business.

On the academic side, forerunners in the field include the Future of Humanity Institute at the University of Oxford, which builds upon research on tensions between technology and humanity. This seems significant as the history of social activism had previously been focusing on the negative impact of technology on humanity and had thus tended to be antagonistic to business.

Governments and funding agencies are also starting to pay close attention. In the United States of America, the National Science Foundation declared its initiative on "Shaping the New Human-Technology Frontier" (Córdova, 2016a). While its funds are to be used for the development of cognitive technologies, the director announced that:

> "*We would fund studies on how technology affects learning, human behavior, and social organizations, and how it will bear on the nature of work and education. And we will investigate how we as humans can shape the future of technology so that it serves to better human life" (Córdova, 2016b).*

In Japan, the Research Institute of Science and Technology for Society (RISTEX), an arm of the Japan Science and Technology Agency (JST) announced in 2016 a new program on the "Human-IT Ecosystem" to promote research on how ELSI can be incorporated into research of advanced information technologies. In particular, the program stresses the application of AI to big data collected by IoT. To differentiate the project from other governmental efforts addressing social issues of technologies, RISTEX declared that it would put into scope only potential technologies and/or potential social issues. At the same time, as part of a larger scheme of promoting research in AI, funding favors the proposal of combining ELSI research with technological developments relying on other government funds.

A JAPANESE PERSPECTIVE: CALL FOR A MULTICULTURAL APPROACH

In efforts to design the funding scheme for the RISTEX project, the team inevitably encountered challenges in addressing cultural and religious diversity. In other words, the power of today's technologies is such as to alter elements of life that are deeply embedded in the cultural context of individual societies. Existing diversity is an issue for the business community because it is likely to affect the acceptance of products in various nations. AI products programmed with one set of ethical values and accepted in one society may not be welcome in others.

A positive illustration of a humanoid in the historic animation "Astro Boy" (Tezuka, 1980), is probably symbolic of the Japanese mind open to artificial beings. While fully aware of the dangers of technology, the creator of the animation assumes the existence of a "warm heart" in humanoids, which can be noticed in the taming of the family pet dog by a humanoid mimicking the dead son of a scientist. This illustrates the acceptance of humanoids having a mind and contrasts dramatically with the way "HAL" in "2001 Space Odyssey" fails to befriend human beings and ultimately is unwired and terminated.

Another notable illustration in Japan is the "Gundam" series of animation. The long-lasting series that started in 1979 portraying humans as evolving (i.e., acquiring new capabilities) into human-like robots by wearing "mobile suits." This is illustrative of the perception of human-technology co-evolution in the Japanese mentality.

Okuno (2002) stresses the role of animism (techno-animism) in the Japanese culture to explain differences in the attitude toward technology. While the Judeo-Christian tradition puts humans above other beings, animistic tradition considers humans merely as part of the larger cosmos, in which everything living and non-living has a spirit of their own. Hence, there is no ground for distinguishing the artificial from the natural. That would mean that there should be no hierarchy that puts humans above other beings.

Such differences in our worldview have implications for what we set as a goal in the harmonization of technology and society. Consistent with our own tradition, the RISTEX project avoided the term "human-centric" and chose Human-IT Ecosystem instead, assuming the symbiosis of humans and technology as well as of the artificial and natural.

Whether and how divergent views of the world can see eye to eye is an open question. Jensen and Blok (2013) point out that animism is not monopolized by the east but also exists in western cultures. Thus they warn against mistaking animism for the human-nature dichotomy often seen in discussions concerning environment. They argue that, *"If Japanese scientific, technological and cultural production is not only hypermodern but also (in some measure) animist, then modernity, too, must be seen as a multivalent form."*

IDENTIFYING DIVERSITY OF ATTITUDES IN THE PROBLEM SPACE

In order to formulate a strategy toward cross-cultural AI-ELSI research, we need to define its problems. While admitting that we lack a clear understanding of the problem space, there are a few apparent questions that are catching the attention of researchers and policy makers. Preliminary observations of how cultural difference affects the approach toward these questions are also possible. Let us lay them out.

Traditional ELSI considerations in IT development

Privacy

Before touching upon the impact of AI, we should mention ELSI that have already been a major concern in the development of IT, namely those surrounding privacy.

The Internet now connects billions of people, allowing a vast exchange of information including personal information. While it offers a wide range of benefits to people, it has also seen a massive increase in privacy violations. Applications on the Internet such as social networks and e-commerce platforms have become databases that may, if inadequately used, monitor and manipulate users.

Privacy in the context of intercultural diversity derives from individualist foundations. The notion of privacy emerged in the process of modernization that transformed collectivistic societies into individualistic ones. Although the idea of privacy has allowed individuals to ward off collectivist intrusions, there are still many societies that are yet to embrace individualism and are therefore less sensitive to privacy.

Emerging artificial intelligence issues

Research in AI has a history of about 70 years with notable literature by Turing (1950) that opens with the question, "can machines think?" Subsequently, the AI research field experienced booms in the 1960s and then again in the 1980s. Now the AI field is in the process of a third upswing. Nick Bostrom's book Superintelligence (2014) is credited with advancing the current boom of AI. Bostrom argues that if machine brains surpass human brains in general intelligence, then this new superintelligence could replace humans as the dominant lifeform on earth if we fail to bring our human resourcefulness to bear on this development. Brynjolfsson and McAfee's book *Race Against The Machine* (2013) is also credited with fostering interest in AI and promoting a sense of fear regarding it. The authors argue that the average worker is not keeping up with cutting-edge technologies and is losing the race against the machine.

On the other hand, there are some who raise doubts with respect to above-described theories. In its report of September 2016, the One Hundred Year Study on Artificial Intelligence (AI100) has only just reported its findings regarding AI and its influence on people and society. AI 100 (2016) argues that AI is not an imminent threat to humankind. No machines with self-sustaining long-term goals and intent have been developed so far or are likely to be developed any time soon.

While optimists and pessimists are divided over the progress of AI, they do share their emphasis on the very power of it. The reason why AI receives so much attention, in spite of the skepticism noted above, is based on the notion that machines may soon become more intelligent than humans, at least in certain dimensions. This immediately raises two key questions.

Responsibility

At the practical level, it raises the question of whether or not we should delegate critical decisions that involve moral issues to machines. If we are to do so, the next big question will be who should be held responsible for the consequences. Thus the dilemma. It may be safer to let machines drive au-

tomobiles, but only humans seem capable of taking responsibility. And if the automobile manufacturers are unwilling to take responsibility for the behavior of their products on the road, we may only be able to supply "machine assisted" driving that shifts responsibility to the drivers, while much of the driving is in fact done by the machines themselves.

We are now challenged to rethink what it means to perceive, think and exist. If we follow Descartes' dictum "I think, therefore I am," should we consider that thinking machines, too, exist as autonomous beings? Such a question is not necessarily purely philosophical, as copyright ownership of machine-produced works of art is receiving serious attention. We may one day decide to tax robots that generate income for themselves. That perhaps, would appear more equitable than giving all of the ownership rights to the original programmer of AI.

It should be noted that the life sciences, as evidenced by rapid progress in genomics, have been grappling with similar issues for the last few decades. The prospect of interventions in the creation of life and in basic human attributes has been the cause of alarm for religious, ethical and philosophical communities. Without going much into the discussion of how, we note that the ongoing debate is leading to the creation of research ethics review institutions and compulsory ethical education for researchers in the life sciences. Some of the concepts in these programs may very well be adopted in the development of advanced information technologies.

In the context of intercultural diversity a major difference would appear in the notion of responsibility based on the view that autonomous minds exist in machines. Admitting it, we would be confronting doubts about the hierarchy of mastership of the world. Clearly, if we are to take intelligence as the symbol of mastership, machine superiority seems to threaten humanity itself by denying its superiority over all other beings. Will human beings become slaves serving the master machine one day?

Employment and income distribution

The fear that machines may destroy traditional jobs has been mentioned earlier in this paper, with an Oxford University study predicting that as much as 47% of jobs may eventually be taken over by machines.

To be fair to technology, the introduction of machines in modern manufacturing has lifted our lives by redistributing the benefits of increased productivity. At the same time, there is a growing recognition that the knowledge intensive industries of today do not create middle-income jobs in the way or on the scale manufacturing industries once did.

It is in this context that the need for a better income distribution system is being debated. One idea is that of "basic income" where the government provides all its citizens with an income sufficient to sustain a basic living standard. It should be noted that this proposal, when combined with the proposal of consolidating various welfare benefits, is in line with the "negative income tax" concept that policy thinkers of the conservative wing advocate. In the case of Finland we already see an experimental version of "basic income" at work whereas elsewhere proposals of this nature receive much attention.

While perhaps less fundamental than the issue of ownership of mind, a sense of diversity appears to prevail across societies in their view of the future of work. We note here surveys by the Japanese Cabinet Office that report a strong and growing willingness of people over 65 years of age to continue their working life (Cabinet Office, 2015). More notably, the reports point to a strong willingness for elderly people to participate in social work. This reflects the Japanese perception of work as an act of self-realization, rather than a mere means of supporting life.

THEORIES RELATING TO CO-EVOLUTION OF HUMANS AND TECHNOLOGY

While noting intercultural diversity in the perception of information technologies, one must also note that culture itself is dynamic and subject to change. There have been many researches on how societies and technology interact and mutually change over time. Thus it should be helpful to explore how humans have been dealing with the interaction between society and technology to this

day in order for us to come to terms with contemporary issues surrounding AI. Let us attempt to do this here from three different standpoints. First, we will look at major society-technology issues (frictions, clashes) in human history. Second, we will review how the relationship between technology and society has been theorized. Third, we will review some efforts in the past attempting to incorporate social perspectives into the development of systems that employ technologies.

The history of events involving the interaction of technology and society

We can perhaps move as far back as the dawn of agriculture as the moment when tensions between technology and society emerged. Ever-improving tools allowed the feeding of larger populations while innovative skills were also applied to create weapons with which to protect both crops and people. The Industrial Revolution of the 18th century came with rapid mechanization and resulted in the deprivation of jobs requiring traditional skills, which led to social movements attempting to destroy the emerging technologies.

In the middle of the 20th century, military, technological, and scientific forces combined as a consequence of World War II. The Manhattan Project (1941–1946) was a symbolic example of this synergy; scientists such as Julius Robert Oppenheimer were recruited to develop the atomic bomb, and the success of this project demonstrated that technology and science could influence society not only in wartime but also in peacetime (Kobayashi et al., 2007). In 1945 Vannervar Bush, a former professor at MIT, wrote the report "Science: The Endless Frontier," based on the experience of the Manhattan Project (Bush, 1945). Bush highlighted the importance of governmental support in endorsing basic scientific research and argued that promoting such research could lead to a prosperous society. This was referred to as the linear model of scientific progress (Pascal, 1999). In those years, optimism about technology blossomed.

By the middle of the 1960s and the first half of the 1970s, advanced countries faced environmental disruption due to increasing industrial development. Rachel Louise Carson's book "Silent Spring" (1962) is credited with advancing the global environmental movement. This movement triggered the establishment of the Environmental Protection Agency (EPA) in 1970 and the Office of Technology Assessment (OTA) in 1972 (Kobayashi et al., 2007). Replacing optimism regarding technology, skepticism came into fashion.

In the 1980s, developments such as the semiconductor and advances in biotechnology and new materials refocused attention on science and technology. High-tech industrials became lighter and more compact than before. The linear model fell out of favor (Kamisato, 2016) and was replaced by the view that science could be used as a force for economic development.

In the 1990s, technology and science came to be viewed from various perspectives. The Cold War had ended and the issue of global warming was now at the heart of the international agenda. The Intergovernmental Panel on Climate Change (IPCC) was established in 1988. The Chernobyl nuclear accident (1986) drew unprecedented public attention to environmental pollution. In 1990, the National Human Genome Research Institute (NIH) in the U.S. began a research program on the ethical, legal, and social implications (ELSI) of genome and genetic research. 3% of the budget of genome R&D at NHI was allotted to ELSI research. The shared mission of the program was to identify, analyze, and address ELSI of the Human Genome Project (HGP) at the same time that basic scientific issues related to it were also being studied (National Institutes of Health and Department of Energy, 2000). Almost simultaneously, the Internet began to be used for consumer purposes rather than only military ones (Kamisato, 2016). Information technology began changing the world, and the information society emerged.

At the beginning of the 21st century, the concept of "science for society" was widespread. A typical example would be the World Conference on Science for the Twenty-First Century, held in Budapest, Hungary and organized by UNESCO and the International Council for Science (ICSU) in June 1999 (Kamisato, 2016). A total of 1,800 science stakeholders from 155 countries participated in this conference. The Budapest declaration, which was adopted at the end of the conference, stated that technology and science should not only pro-

duce knowledge but also account for its use. The previous function of science for knowledge was thus augmented by three new functions: science for peace, science for development, and science for society (Moniz, 2016). The Budapest conference was said to be the first global conference for science and society, and it influenced many subsequent technological and scientific policies.

In the 2010s, the term "responsible research and innovation" (RRI) gained increasing policy relevance (Owen et al., 2012). RRI indicates that societal actors collaborate and work together throughout the research and innovation process. In RRI, ethical issues are regarded as design factors rather than obstacles (Yoshizawa, 2013). Furthermore, responsiveness to the public is seen as one of its key concepts. Hence, "science with society" became another recognized function of science.

Human thoughts about technology and society from the social science perspective

Technological determinism has long been dominant in academia. While we see elements of determinism in philosophical thoughts from Greek times onward, the term "technological determinism" is believed to have been coined by the American sociologist Thorstein Veblen (1857–1929) who argued that the progress of cultural values and social structure is due to the technology a society possesses and that the advancement of technology follows a predictable, traceable path largely beyond cultural or political influence (Veblen, 1921).

Wiebe Bijker and Trevor Pinch introduced an alternative view which emphasizes the social construction of technology (SCOT). In contrast to the linear model of technological determinism, Pinch and Bijker (1984) argued that technological innovation is an open process that can produce different outcomes depending on the social circumstances facing development. They also argued that applications of technology cannot be completely understood without first understanding how that technology is embedded in its social context (Bijker and Law, 1992). Thus, human action shapes technology.

The two theories noted above represent contrasting models of innovation. The view that humans are independent from the rest of the world is common; however, opposing theories are also common, such as Michel Callon's actor network theory (ANT), which argues that such a divide does not exist and society and technology are developed by hybrid communities including humans and nonhumans (Callon, 1980; Latour 1987). The most noteworthy feature of ANT is that it considers nonhumans as strategic players with the same competencies for innovation as humans. ANT thus reflexively shapes the concept of humans in a new form. Hence, Callon argues that it is necessary for humans to be represented as a form of agency. In the near future, nonhuman devices such as wearable devices will be embedded in the human body and autonomous AI is said to emerge. Therefore, Callon (2004) also states that considering the importance of ICTs, the concept of ANT will become even more prominent.

Human thoughts about technology and society from the systems approach

Technologies are often adopted as an integral part of a system. Thus, the actual process of technology dissemination is built into the systems design and construction process. Here, a notable line of thought is offered by Peter Checkland, who advocated the introduction of the "soft systems approach (SSM)" as opposed to the "hard systems approach" (Checkland and Pulter, 2010). Hard systems assumes a priori fixed problems and seeks to provide optimal solutions to solve the problem. Checkland argues that, in the 1970s, hard systems was the dominant method for systems development used to solve social problems (Checkland 1981). While effective in relatively simple projects, this approach fails to solve the complex nature of real-life experiences where the problem requiring a solution keeps on evolving as technology and society interact in response to change. (Kijima, 2002).

SSM introduced the notion of worldview, which is essential for addressing issues related to human social complexity. SSM proposes that when we interact with real-world situations, we make judgments about them on the basis of a set of values that varies from person to person. Thus, the concept of worldview was developed, with a built-in tendency to view the world in a particular way. SSM is a methodology that aims to address unstructured

real-world problems through exploration and accommodation and bring about improvement in the problem situation. (Checkland, 2010).

EXPLORING THE PATH TOWARD THE DEVELOPMENT OF A HUMAN-AI ECOSYSTEM

A review of literature on human-technology interaction seems to support the view of Jensen and Blok (2013) that diversity exists in this interaction even within the industrialized societies. Recognizing alternative views of the world around AI raises the need for exploring just what they are and how they are expressed. Of particular interest would be the "nonhuman-centric" view. On the other hand, techno-animism observation suggests a view that posits humans as a humble component of an ecosystem of living things, if not merely as a cosmic element alongside non-living things. Codes for developing AI technology in this world-view would be very different from those in the human-centric one. Given these observations we shall conclude this paper with an attempt to lay out some propositions which may enable us to check the veracity of these different views.

Our first proposition will have to be the recognition that cultural diversity exists among cultures regarding AI, particularly in their relative perceptions of the existence of the human mind and of "mind" when referring to artifacts.

Proposition 1: There is a significant difference among eastern and western cultures in their acceptance of machines as mindful beings.

An extension of this in terms of techno-animist theory would be that the animistic tradition of the Japanese will tend to accept that non-living artifacts may have a mind of their own.

Proposition 2: Japanese tend to be more accommodating to the notion of machines as mindful beings.

While predicting cultural (and therefore societal) biases, Jensen and Blok (2013) warn against simplistic dichotomy points at the possibility of hidden tendencies in western cultures that in fact accept animistic views. Our historical account of human social attitude toward technologies provides some hints at where such tendencies may become more visible. One likely area is in the area of genetic engineering that has been grappling with the issue of what artificial intervention should or should not be allowed. Like AI, genetic engineering can be lifesaving, while it has the potential for changing the meaning of life itself. Some think intervention is acceptable to non-humans while its application to humans is not, which seems to be a reflection of the human-centric view. This leads us to speculate that those who take a positive view of applying genetic engineering to human cells are likely to be more accommodating to the idea of AI as a mindful being.

Proposition 3: Those who tend to be more open toward applications of genetic engineering tend to be more willing to accept AI as a cognizant being.

In contrast, environment-conscious people tend to emphasize the impact of human beings on the environment and the importance of preserving it for human's sake. This leads us to speculate.

Proposition 4: Those who are concerned about environmental protection tend to be less open to recognizing AI as a mindful being.

The final point cannot be stated in the form of a proposition as its verification is difficult. Let us present it anyhow in view of its importance as follows:

> *It is possible to create a shared platform for cross-cultural exchange of views around AI-ELSI, one that promotes consensus on universal codes of AI applications in technology.*

The ground for such optimism is that we are very close to seeing many AI equipped machines doing wonderful things in our lives. Applications of AI in robots, which assist the elderly and the challenged, for example, are already on the way to greatly increase the quality of life of many. And yet, without a global consensus on ELSI design requirements the global deployment of such products and others will either be chaotic or severely restricted. No doubt, that would be a great loss to both the economy and society; a mistake that everyone would want to avoid.

Reaching such a consensus, at the same time, requires a renewed understanding of some of the basic values of human beings. We may also need to adopt a compromising approach of reaching a common rule without sharing common values.

Nevertheless, in order to reach such a compromise, we should at least seek a better understanding of how different cultures view minds.

A common ideal for all of humanity must be to build an ecosystem of humans and AI in which both evolve in harmony. To this end, we should continue to research and conduct active dialogue.

REFERENCES

Bijker, W. E. and J. Law. (1992). *Shaping technology/ Building Society: studies in sociotechnical change*. Cambridge, Mass., MIT Press.

Bostrom, Nick. (2014). *Superintelligence: Paths, Dangers, Strategies*. Oxford University Press.

Brynjolfsson, *Erik and Andrew McAfee. (2011). Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*. Digital Frontier Press.

Bush, Vannervar. (1945). *Science, the Endless Frontier: A report to the President*. U.S. Government Printing Office.

Cabinet Office (2015). *Annual Report on the Aging Society: 2015 (Summary)*, Chapter 1 Section2, http://www.8.cao.go.jp/kourei/english/annualreport/2015/pdf/c1-2-1.pdf (last accessed January 11, 2017)

Callon M. (1980). The State and Technical Innovation: a Case Study of the Electrical Vehicle in France. *Research Policy*, 9:358-376.

Callon M. (2004). The role of hybrid communities and socio-technical arrangements in the participatory design. *Journal of the Center for Information Studies*.

Checkland, P. (1981). *Systems Thinking, Systems Practice*. Chickester,UK. Wiley.

Checkland, P. and John Pulter. (2010). Soft Systems Methodology. *The Open University*: 196–200.

Córdova, Frances. (2016a). NSF Ideas for Future Investment, presentation material at National Science Board Meeting on May 6, 2016. https://www.nsf.gov/attachments/137508/public/nsf_future_investments.pdf. (last accessed September 17, 2016)

Córdova, Frances. (2016b). Remarks at Hong Kong University of Science and Technology Hong Kong on June 20, 2016. http://www.nsf.gov/news/speeches/cordova/16/fc160620_hongkong.jsp. (last accessed September 17, 2016)

Frey, Carl Benedikt and Michael Osborne. (2013). The Future of Employment: How Susceptible are Jobs to Computerisation? http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf, September 17, 2013. (last accessed August 17, 2016)

Jensen, C. B. and A. Blok. (2013). Techno-animism in Japan: Shinto Cosmograms, Actor-network Theory, and the Enabling Powers of Non-human Agencies. *Theory, Culture and Society* 30(2): 84–115.

Kamisato, Tatsuhiro. (2016). The possibility of applying Ethical, Legal and Social Implications (ELSI) to information technology. *Journal of Information Processing and Management*: 875–886.

Kijima, Kyoichi. (2002). Soft Systems Approach. *The Journal of the Japan Association for Social and Economic Systems Studies*: 52–53.

Kobayashi, Shinichi, Tadashi Kobayashi and Yuko Fujigaki. (2007). Sociotechnical. *The Open University of Japan*: 59–79.

Kurzweil, R. (2005). *The singularity is near: when humans transcend biology*. New York, Viking.

Latour, B. (1987). *Science in Action: how to follow scientists and engineers through society*. Cambridge, Mass., Harvard University Press.

Moniz Antonio and Kumi Okuwada. (2016). *Technology Assessment in Japan and Europe*. KIT Scientific Publishing.

National Institutes of Health and the Department of Energy (2000). *A Review and Analysis of the ELSI Research Programs at the National Institutes of Health and the Department of Energy (ERPEG Final Report)*. https://www.genome.gov/10001727/erpeg-final-report/. (last accessed October 22, 2016)

Nye, J. S. (1988). *Nuclear Ethics*. Free Press.

Okuno, Takuji. (2002). *Human, Animal, Machine: Techno-Animism* [Ningen, Doubutsu, Kikai: Tekuno-Animism] Tokyo: Kadokawa.

One hundred year study on artificial intelligence. (2016). Artificial Intelligence and Life in 2030. 4–5. (https://ai100.stanford.edu/2016-report)

Owen, R., P. Macnaghten and J. Stilgoe. (2012).

Responsible Research and Innovation: From Science in Society to Science for Society, with Society. *Public Policy* 39:751–760.

Pascal, C. B. (1999). The History and Future of the Office of Research Integrity: Scientific Misconduct and Beyond. *Science and Engineering Ethics* 5(2): 183–198.

Pinch, Trevor J., and Wiebe Bijker. The Social Construction of Facts and Artifacts. In Deborah G. Johnson and Jameson M. Wetmore (Eds.)(1984). *Technology and Society Building Our Sociotechnical Future*. 14:107–140. MIT Press.

Tezuka, Osamu. (1980). Astro Boy 1980 Ep1: The Birth of Atom (Japan Edit). https://www.youtube.com/watch?v=lHiWneCpe9o. (last viewed September 26, 2016)

Turing, A. M. (1950). Computing Machinery and Intelligence. *Mind* 59(236): 433–460.

Veblen, Thorstein. (1921). *The Engineers And the Price System*. Batoche Books.

Yoshizawa, Go. (2013). Responsible Research and Innovation. Beyond ELSI. *Japan Society for Research Policy and Innovation Management*: 112.

Dr. Jiro Kokuryo is professor of Keio University, Japan. Email: jkokuryo@sfc.keio.ac.jp
Ms. Akiko Kaya is Associate Fellow of Japan Science and Technology Agency, Japan. Email: akiko.kaya@jst.go.jp