Ethical, Legal and Social Implications (ELSI) of the Emerging Use of Communication Robots in Care Settings

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ABSTRACT

Advanced robotics has been introduced in the medical field since around the turn of the 21st century. The ethical, legal and social implications (ELSI) of the communication robots used in care settings have apparently received less attention. This study aims to comprehend the research and development trends of such inventions and to (preemptively/proactively) consider the actual as well as impending ELSI of communication robots. For this purpose, I conducted keyword searches of the database provided by Japan Patent Office (JPO) and examined the inventions, alongside of reviewing literature on ethical discussions using PubMed. The search revealed a mismatch or contradiction between invented products and ethics debates. The database search yielded robots with diverse forms (appearances), functions and applications. The artificial intelligence implemented in the robots found in the patent application documents is far from the envisaged levels. Also, some of the concerns in the literature that received less attention are already factual issues. Robots resembling humans or animals apparently evoked emotional responses from users, especially vulnerable people. Such usages can entail deception and artificially produced reality in the absence of real human beings or animals, leaving users feeling deserted. Considering the status quo, the ELSI of communication robots are discussed.

Keywords: Ethical, legal and social implications (ELSI), robots, communication robots, patent, care settings

1. Introduction

1.1 Background

According to "the Collingridge dilemma," when a technology is emerging, it is difficult to foresee the ethical, legal, and social implications (ELSI) of the said technology, whereas when the need for control becomes tangible, the technology is entrenched and hard to control.[1] Meanwhile, among the major trends in healthcare today is an increasing integration of engineering technology. Above all, advanced robotics has been introduced in healthcare since around the turn of the 21st century. As is well-known, robot-assisted surgery and robots transporting medical records are already in practical use. Japan has been an international hub of robotics, with several notable examples of robotic products. Correspondingly, in the country, the robot industry has been recognized as one of the future key industries by those in industry, government, and academia.[2]

Robots termed communication robots are currently being put into practice. Such robots developed in Japan, including Paro by the National Institute of Advanced Industrial Science and Technology, and Hugvie, by Vstone Corporation, are primarily intended for psychological healing (robot-assisted therapy) of elderly people's minds. For some, the use of robots is a promising option in the aging era.[3]

Whereas the ongoing trends mentioned above apparently require thorough and timely examination of the ELSI, the disputes related to robots both in Japan and in the Western countries are said to have centered on such topics as

'*cyborgization*' (partial robotization of human bodies), autonomy, including the possibility of becoming moral agents driven by exponential advances in artificial intelligence (AI).[4] Despite the increasing interest in the ELSI of robots, which led to the coinage of "roboethics" in 2002,[5] the ELSI of the communication robots used in care settings have apparently received less attention. The aim of this paper is to comprehend the state of the art of communication robots and actual as well as impending ELSI of their use, alongside of ethical discussions found in literature.

1.2 The scope of inquiry

To carry out this project, we must get a sense of what constitutes "communication robots." In fact, to appropriately consider something, we must know it beforehand (the hermeneutic circle). Nevertheless, the idea of "robot" is nowhere near unambiguous. A senior editor at IEEE Spectrum estimates that less than twenty percent of robots have been used in factories for manufacturing today.[6] These robots are called industrial robots. Other robots help humans in more personalized settings. Robots that fall into this category are often called service robots (e.g. Roomba, a robotic vacuum sweeper by iRobot). Many industrial robots resembling arms as well as Roomba may divert from what people regard as "robots."

According to the International Organization for Standardization (ISO) (ISO 8373:2012),[7] "service robot," in contrast to "industrial robot," is a "robot that performs useful tasks for humans or equipment excluding industrial automation applications." In their classification, together with a "surgery robot in hospitals," a "delivery robot in offices or hospitals" and a "rehabilitation robot" are labeled as "service robot for professional use." Nevertheless, Bekey states that "there is still a lack of consensus among roboticists on how they define the object of their craft."[8] A working definition proposed instead – "a machine, situated in the world, that senses, thinks and acts"[9] – is substantially flawed, because manufactured robots have never succeeded in thinking as humans do. Also, if the attribute 'independent/autonomous transferral', albeit in a limited manner,[10] is part of the definition, androids that currently draw attention are excluded. For example, "geminoid" by Ishiguro's group cannot move independently. And "telenoid" by the same group is also excluded.[11] Some may think excluding these is counterintuitive. Meanwhile, some arm robots can be interactive. They have sensors and "memorize" movement by "robot teaching" or "teaching playback." In 2016, the Ministry of Health, Labor and Welfare (MHLW) decided that robots require sensors, hence excluding highly demanded care lifts without sensors.[12]

"Communication" is no less ambiguous. An important question is what constitutes communication. Mere "interaction" seems overly broad. Some kind of interaction apparently exists even between a hand and a pebble in it. As in some applications, arm robots can be interactive or communicative by having displays or memorizing the motions of users (e.g. 2008-178973). Holding hands (2007-185763) may be arguably a form of communication.

The search results are retrieved not because they are actually robots but merely because applicants used the term robots to describe their inventions, irrespective of their true nature. For the purpose of this study, namely to enable proactive consideration of the ELSI, I tried to include what engineers consider to be robots used in care settings.

I adopted a broader understanding and then excluded irrelevant results, considering that the broader the definition, the more comprehensively the potential ELSI are grasped proactively. In this study, communication robots used in care setting are roughly defined as robots designed to affect humans in care settings, but not used for surgery, diagnosis or other conventional medical purposes, excluding robotic surgery, cyborgization, and other devices.

2. Method

To understand the research and development (R&D) trends of the field, I chose patent applications as the primary source of information and conducted keyword searches of databases provided by the patent office in Japan. I used Patent Application of Japan (PAJ ; https://www19.j-platpat.inpit.go.jp/PA1/cgi-bin/PA1INIT), which is the database of the Japan Patent Office (JPO), one of the three

largest patent offices in the world. The search was limited to Japanese patent application publications and Japanese translations of Patent Cooperation Treaty international application publications with English translations. The results of keyword searches were analyzed using the application documents. With a future survey of other patent databases overseas in mind, I used English words as the search words.

In the case of machinery including engineered robots, the structure of inventions is easily known by disintegration, a process termed "reverse engineering." Reverse engineering is not prohibited as illicit obtainment of trade secrets, whereas the legality of special stipulations to prohibit reverse engineering of programs remains controversial under the Antimonopoly Act. This is a prominent difference from inventions in other fields, such as pharmaceutical agents and chemical substances. One cannot easily find out how a substance is synthesized by analyzing the final product. In the case of engineered robots, such secrecy is unlikely, which is the rationale for patent application searches. Also, the application fee may help exclude inappropriate documents as people usually avoid paying for nothing. Since inventors can choose not to file a patent, I supplemented the patent application document search with the Internet search.

Rejected patent applications and other applications that have not been requested for examination are not excluded (Patent applications to the JPO are basically automatically published 18 months after the application, but applicants can choose to or not to make requests for substantive examination). This is primarily because even after the registration of patents, they can be invalidated. Although the ratio fluctuates each year, approximately half of the requests for invalidating registered patents are successful. Meanwhile, rejection does not prevent the inventions from being marketed.[13] Therefore, applications, whether successful or not, are considered to reflect R&D trends.

Subsequently, I reviewed the literature using PubMed (http://www.ncbi.nlm.nih.gov/pubmed) to comprehend arguments on the ELSI made so far. Three sets of search words were used: ethics and robot* and care; ethics and robot* and therapy; ethics and robot* and communication. An asterisk(*) was added to cover derivatives of the word robot. As surgical robots were not within the scope of this study, the word "treatment" was not used as a search word. Considering a likely criticism that the databases selected are basically medical, to supplement the keyword searches in the above database, relevant publications including academic as well as commercial articles were collected from the citations and the internet searches.

3. Results

Since many robots resembled humans or animals, based on the literature and the patent applications, I classified the inventions into 4 categories: human-form, simplified human-form, animal-form, and others, though strict demarcation among these categories is unrealistic.

The JPO database search results as of December 31, 2016, revealed that seven results of the search with "robot" AND "therapy" in Abstracts included inventions intended for conventional medical approaches (e.g. radiation therapy). None was relevant to the current research.

The search with "robot" AND "care" in Abstracts yielded 59 results. The results included a number of inventions intended for assisting transfer. Unsubstantial/unfeasible applications excluded, 6 were relevant to our interest. One (2002-000574) has a simplified form robot intended as an interface for information exchange between caregivers and the cared-for. Another (2002-261966) is an animal-form robot primarily intended "to provide mental care for loneliness by simulating human conversations." Another animal-form robot (2003-089077) is allegedly capable of "allowing a user to learn the cultivation of aesthetic sensitivity for the respect of life through care, such as meal and excretion." A robot with simplified form (2005-305631) is intended for "taking care of or managing a child." An unidentified (or simplified form in the application document) form robot (2010-140119) is capable of "acquiring the physical information of a user" and "expressing an operation based on the determined operation pattern to the user through movement," thus encouraging health promotion of users. A simplified form robot resembling an infant (2012-220783) allegedly "awakens in aged persons, care recipients, etc.

the feeling of nursing, to suppress the decay of their mental functions and is capable of supporting them in finding value and reasons for living." In addition, an unidentified (or simplified in the application document) form robot (2003-339796, deemed to be withdrawn), is intended for collecting data of "a behavior" that a disabled person "hesitates to ask a care-giver to do."

The search with "robot" AND "communication" in Abstracts yielded 1,139 results. Thus, I reduced the results by adding a condition ("robot" OR "communication" in Titles of inventions), obtaining 782 results. The great majority of the oldest applications were those of industrial robots. Except for industrial robots, the results included applications irrelevant to the survey, such as communication method or system, and controlling system. In some cases, communication referred to interaction between robots or that between a robot and a database. Applications lacking substantial information were excluded. Also, the results included several applications that concerned one invention. For example, an application by Sony (2001-222317) is a monitoring system used on AIBO (a canine robot whose production discontinued in 1999). To avoid redundancy or duplication, the most relevant application was chosen for analysis. Sixty applications were analyzed as relevant to our inquiry. A simplified form robot with unidentified purposes (07-140997(1995)) features "voice synthesizing means and a voice detection means." One application (2001-246580), implementable on AIBO, is said to obtain information on the condition of health of a user and is based on the information the robot generates by voice. Another with a simplified human form (2001-260063, deemed to be withdrawn) communicates with gestures "using limbs and/or a trunk part." One with a simplified form (2002-000574, deemed to be withdrawn) is an information exchange platform between caregivers and the cared-for. An animal-form robot with an unidentified form (2002-160184) features a technology to process images. The inventions (2002-239971, rejected; 2003-305669) are an animal-form telephone for the elderly or children that can show motion during conversations. An animal (canine)-form robot (2002-261966, deemed to be withdrawn) is intended " to provide mental care for loneliness by simulating human conversations and to watch whether there is anything wrong by transmitting an image to a mobile terminal within the extent [of] not invading privacy." Another animal (canine)-form robot (2003-062776, rejected) is "a wake-up call" robot-dog and "a watchdog" accessed from a mobile phone. Another application (2003-275981) with unidentified form plays recorded voice. A "communication terminal" (2004-048186) consists of a robot with an unidentified human form robot connected to the Internet, capable of playing the received messages. The invention of a human-form (humanoid) robot on a chair with wheels (2004-058166) focuses on its position/postures and appearance that might consequently reduce discomfort during communication. Advanced Communications Research Institute International (ATR), based in Kyoto, with Hiroshi Ishiguro, a famous roboticist, filed 51 applications. These applications were mostly intended to make responses of a robot less monotonous. Other relevant applications were the following: a robot exemplified by a simplified-form (2010-128281) that nods when detecting the end of an utterance (sound), pretending that it was listening to the speaker; a simplified human-form robot (2013-169611, rejected) receiving "exercise plan information from a mobile terminal" for a user and records and transmits the results; a communication interface exemplified by a form of a small bird that can emit light and sound (2015-065503); a mobile interface "incorporating cloud computing" with a display (2015-092348 and others); and a remote-controlled (2015-093353) robot exemplified by a simplified human form robot with a display on the face, showing the opponent real-time. The application 2015-184597 is a communication robot for an elderly person equipped with a display showing collected images and "a video phone which enables the family member to directly respond to the elderly person." This robot synthesizes sentences based on data from conversation with family members. "Partner robot" (2016-101441) primarily intended for "a single-living elderly person" responds to the user with simple gestures. An application with a voice recognition system with "a database, in which a plurality of conversation patterns that the companion and robot speak are registered," has an unidentified exterior (2016-118592).

Very few applications before 2000

concerned our inquiry. Among the search results, no application publication before 2000 included robots with human, simplified human or animal forms.

A search on PubMed yielded 65 results with robot* and therapy and ethics, 53 with robot* and care and ethics, and 32 with robot* and communication and ethics, as of December 31, 2016.

In the first group, 11 results did not have English abstracts and thus were excluded. Three contained the word robot only in irrelevant manners. Among the remaining, 30 dealt with surgery and other types of physical interventions, including biopsy and intubations, or mentioned ethics in irrelevant manners. Nine, some of which discussed cyborgization or AI, were also irrelevant to our inquiry. Seven articles were relevant to this research. The second group of search results contained 20 identical articles with the former and 9 without English abstracts. Among the remaining articles, 7 discussed surgery and related techniques. Nine did not mention ethics in relevant manners or were irrelevant to care robots, and some of these dealt with autonomy, intelligent robots, and brain computer interfaces. Seven were relevant to this study. The third group included 16 articles that have been already mentioned in the previous groups and 5 lacking English abstracts. Eleven did not mention ethics in relevant manners, or were irrelevant to care robots, discussing post-humanity, surgery, and AI. Only one was relevant to this study, but discussed the issues in a general way.

The first authors of the relevant articles belonged to institutions in Austria, Canada, France, Germany, Netherlands (3), the United Kingdom (3), United States (4), and Sweden. One second author was Japanese (H. Ishiguro).

The above relevant articles contained arguments for the importance of ethics in the use of robotics in care settings, and the resulting necessity to implement ethics in robots and to create a framework for discussion on robot companions' responsibility and (potential) rights. Detailed, specific arguments are presented in the discussion section.[14]

Some other academic and non-academic articles were collected to supplement the keyword searches. The most comprehensive list of the ELSI was found in the Roboethics Roadmap, which apparently has learned much from medical ethics.[15] The drafted Robot Ethics Charter announced by the Korean Ministry of Commerce, Industry and Energy, in 2012, relied on the EURON Roadmap.[16]

4. Discussion

The use of the robots in the results varied extensively in detail. This may be partly due to the compound nature of care.[17] Also, many of the robots examined above were more like toys, irrespective of what roboticists and manufacturers may insist. Many applications were intended for making monotonous responses of robots more complicated, for example, by accessing databases. Just as strong medicines have strong adverse effects and those of weak medicines are weak, "adverse effects" of the current robots examined seem to be weak.[18] On the other hand, the divide in accessibility to care robots is unlikely to be translated into the divide in health level. Nevertheless, some of the concerns in the literature that received less attention are evident in the current use of communication robots as described below.

4.1 Ingenuity of roboticists and diverse purposes

The search yielded robots with diverse forms (appearances), functions and purposes. Truly versatile robots seem futuristic. Instead, different robots had different purposes. The usages of inventions are so diverse that those seeking for the ELSI can hardly anticipate them, as exemplified by robots for teaching "respect for life" (2003-089077). This may partly be explained by the gap between ingenuity of engineers and other fields, including practice, in healthcare settings (especially when roboticists are inspired by the "seeds" from academia, rather than the "needs" of industry). As far as the present study is concerned, it is unlikely that engineers educated primarily in engineering have undertaken medico-ethical education or consultation, unless they explicitly focus on the development of medical machinery. The diverse purposes of inventions resulting from roboticists' ingenuity may render (proactive) regulation

difficult, whereas its – actual or impending – consequences deserve close attention.

Further, some robots were used as platforms for applications. For example, without applications, Pepper is similar to a computer without software. Anybody can develop applications for the robot. This democratization and decentralization of development of robots can undermine attention to ethics, with anonymous engineers less governable.

4.2 Implications of underdeveloped AI

AI for communication implemented in the above robots is far from the envisaged levels. They have very limited or minimal capabilities of verbal communication, natural conversation being practically impossible, unless rehearsed.[19] They may synthesize sentences but do not understand the meaning as humans do. Therefore, integrating concepts of ethics, responsibility and (potential) rights with robots remains futuristic and far-fetched. This absence of any comprehension or understanding on the part of robots also implies that, at least at the moment, those robots cannot readily replace vibrant interactions between the cared-for and their caregivers. A decade ago, in Sony's AIBO, for example, only limited response patterns were installed. Some users felt that their relationships with the robots were not developing (but for some, their experience was totally different, as described below). Although such shortcomings can be addressed by technological progress, the situation has not changed much.

People expect intelligent reactions from robots with human-like appearances. In reality, however, the inventors of the above applications were simply making their robot responses less monotonous. In a public lecture held in Nagoya on March 25th, 2015, vice-president of Toyota Motor explained that Kirobo is only 30-cm tall so that users will not expect intelligent and sophisticated reactions from the robot.[20]

Search results revealed that, among three categories of ethical issues relating to robots (1. ethics involved in manufacturing robots; 2. ethics that robots should adhere to. 3. ethics toward robots),[21] the second and the third were less relevant, as they are concerned with autonomous robots. Even though "one day robots could become moral agents,"[22] artificial moral agents or programming new "Asimov's laws" for health care settings remains futuristic at present (Though futuristic, eventually robots that are genuinely moral agents will have to obey the same moral principles as ours).

4.3 Exteriors or appearances

4.3.1 Advantages/disadvantages of human-like exteriors

As advantages, human-like appearances of robots may help mitigate the fear of users. Also, if they can move as humans do, they can use tools and infrastructures designed for humans. Nevertheless, robots with such appearances or forms are not always the best solution. Despite a popular association between walking with two legs and intelligence, a consequence of biological evolution, bipedal walking is not necessarily advantageous for specific tasks. Considering the formidable technological difficulties in bipedal walking, it should be reminded that human-like appearances are not necessary for every purpose and possibly counterproductive (e.g. In the nuclear power plant accidents following the natural disaster, walking robots made no contribution.). In fact, useful robots have often simpler exteriors.

An unsigned article states that Japan's robot industry has been shackled by the phantom of Astro-Boy, the main character in a popular comic series written by Osamu Tezuka through the 1950s and 1960s.[23] ASIMO, the robot by Honda Motor, cannot perform tasks more than carrying coffee. The robot remains a mere mascot or toy.

4.3.2 The importance of or dependence upon exteriors

In the face of underdeveloped AI, most of the robots used for communication depend largely on their appearance than on AI.

4.3.3 The significance of animal-form robots

In the search results, robots with animal appearances were as common. Although some suggest that "humans are more likely to bond with a robot if it has a high degree of 'human-likeness,'"[24] given the status of pets (companion animals), it is not sufficient to consider attachment exclusively in terms of "human-likeness." Also, if "a robot's 'personality' will be primarily a byproduct of a person's

anthropomorphization of the robot's appearance and actions,"[25] then such anthropomorphization may extend to robots resembling animals. In humanoid robots, the Uncanny Valley hypothesis is widely recognized. According to this hypothesis, slight differences between humanoid robots and real human beings evoke a sense of discomfort or unpleasant sensation in those who see the robots. If this hypothesis applies differently between human-form and animal-form robots (and I think it does), animal robots require special precaution.[26] Put otherwise, robots resembling animals can effectively evoke their users' attachment.[27] The above difficulty of humanoid robots and the relative easiness to develop animal-form robots may make the latter category promising.

4.4 Evoking inappropriate feeling or emotion and exploitation thereof

4.4.1 Attachment and negative feeling or emotion

Negative emotions and attachment evoked by robots deserve attention, as some robots have evoked emotional responses from (often vulnerable) users. Some care robots in the search results exploited negative emotions, such as uneasiness or pity. This contradicts a *prima facie* maxim that "it is desirable for robots to elicit positive emotions and, as much as possible, avoid producing negative ones."[28] Potential robotic usages to evoke negative feelings may include punishing, complaining, reprimanding, ordering, and instructing. Even if appearances, movements, emotions or intelligence implemented in robots are artificial, emotional responses evoked by such robots are truly human. Given the possibility of attachment users can have toward robots with specific forms,[29] human- or animal-like appearances – especially if implemented not merely with the human forms but with the exteriors and movements imitating human or animal skin and facial expressions – can pose a risk with potential adverse effects.

There is a fundamental question of whether or to what extent having negative emotions should be avoided, admitting that the negativity may be a constituent part of human beings. At least, causing negative feelings or emotions is itself problematic, as these are experiences that people wish to avoid. These concerns are categorized as concerns regarding ethics involved in manufacturing robots.

As shown above, the issue of exploiting emotions is not limited to the most advanced robots: underdeveloped robots share this issue, which can be exacerbated by the increasingly elaborate appearance of robots and the advancement of AI. Even without a human- or animal-form appearance, a device that "gives an emotional stimulus to the person in front of the digital camera" by displaying images of different facial expressions of pets (2004-227167) can entail similar problems. Jibo, a robot butler developed by MIT, has adopted a similar strategy. With minimal bodily movement, the images on the display play the crucial role.

4.4.2 Deceptive Usages

As shown in the above examples, central characteristics of the use of robots include intended deceptiveness to varying degrees; some robots, especially with human or animal appearance, are designed to deceive people or provide some artificially produced reality in the absence of real human beings or animals, which can leave users in some way feeling deserted or alienated. Especially, people with cognitive impairment may mistake humanoid robots for humans. It is true that we sometimes enjoy being deceived wittingly. For example, at Disneyland, we see Micky Mouse instead of a person wearing a mouse suit. However, deceptive usages seem justifiable only in limited cases. The current robots used as security guards are not very different from multiple surveillance cameras connected to security companies. Robots with human-like appearances should be more effective since criminals would prefer not to be surveilled by human beings. Otherwise, a deceptive use of communication robots should be justifiable when, paradoxically, the user is not deceived. A procedure analogous to informed consent may help.[30] Presumably, more comprehensive, concrete guidelines for the ELSI of communication robots (e.g., avoidance of unjustifiable deception based on anthropomorphism or zoomorphism[31]) need to be elaborated and substantiated to deal with these aspects.

Details of deception vary. One of its

forms is wrong assurance, found in the use of a "nurse robot," whose benefits I do not consider prevailing over deficits.[32] The nurse robot simply nods in a physician's office. This usage clearly shows the multi-purpose nature of a humanoid robot. The researchers reported that its presence encouraged dialogues between patients and healthcare professionals and enhanced patients' evaluation of physicians. The intended usage not only disguises the presence of a nurse but also disguises endorsement by a nurse to the physician's practice. The anxiety of a patient, which might be mitigated by the presence of a nurse robot, is considered a problem only when it disturbs communication or careful, informed decision-making. Otherwise, the anxiety is only a natural precaution, encouraging deliberate choice. Influence on decision-making, especially in the healthcare setting, can have grave consequences. In this case, the use can prevent a patient from making a careful decision, which renders this usage plainly unjustifiable. Presently, technologically speaking, artificial muscles mounted on this robot require a huge apparatus. Such low cost-effectiveness makes the nurse robot unlikely to be practically used in the healthcare context. To improve moods of patients, smaller robots will do. The purpose does not justify deceiving patients by means of human-like appearances even if "every technology can be misused."[33]

4.4.3 Being left to robots

If we presume that the robots examined above can fully replace communications between human beings, we are misguided. Arkin stated "The real question from an ethical perspective involves the incorporation of human psychological models to tap deeply into an emotional vein unbeknownst to the observer. Tapping into this deep emotional source is, in many ways, a method already utilized in advertising, cinema, video gaming and other forms of entertainment. The physical embodiment of these robots, however, adds a special dimension that has caused concern among some ethicists and philosophers, particularly in terms of our society abrogating its responsibility for maintaining and enriching human-human contact with the aging. The use of such robots, according to this view, essentially provides an artifact displaying an illusion of life, thus encouraging a further loss of contact with reality by the elderly."[34] We saw that the concerns expressed here were already evident in the current use. Some may think that robots can communicate with people, especially elderly or cognitively impaired persons, in place of them.[35] However, the above robots cannot replace human beings, leaving the vulnerable deserted. The best part of communicating with other human beings and companion animals is that we cannot control them and they transcend our expectations. Communicating only with programmed objects or underdeveloped AI, which is the status quo of current technological applications, can deprive the cared-for of experiencing vibrant communication. Also, to prevent deterioration in the cognitive abilities of the elderly, their family or caregivers, rather than robots, should seek to communicate with them.[36] The use of robots for this purpose is justifiable when it does not reduce the amount of or undermine the quality of their communications with people around them or when complex communication with other people is more burdensome than beneficial to users as in the case of KASPAR developed for autistic children at the University of Hertfordshire.[37]

4.5 Regulative problems

The above robots can entail regulative problems beyond approval by an institutional review board of each institution. Article 2 of the Pharmaceutical and Medical Device Act of Japan, whose 2014 revision did not change the definition, defines a medical device as a device used for diagnosis, treatment, or prevention of a disease or a device intended to affect the physical structure or function of humans or animals (specified by a Cabinet Order). Based on the findings from the database search, this definition is too restrictive to cover the diverse purposes and the breadth of the current and potential usages of the communication robots. Many robots aimed at affecting users' emotions may not be regulated as a "medical device." Although Hugvie – a huggable phone – could mitigate stress when used as the platform for telecommunication,[38] this usage does not necessarily fall into the category of "treatment." Robots intended to change moods of users can be potentially harmful. One possible path is to extend the definition of a medical device to include such robots, but it is

simultaneously necessary to prevent regulations from being excessively broad, to deter R&D activities. If emerging usages of communication robots are not to be regulated as medical devices that require the evaluation of risks and adverse effects in advance, the authorities need to contrive ways to regulate the emerging usages of robots.

4.6 Japan's presence

Despite their leading roles in robotics,[39] judged from the search results for the ELSI, Japanese researchers made relatively smaller contributions, at least internationally, concerning ethical questions relating to care robots. In contrast to "a common theme in American science fiction in which the creation of robots leads to a dystopian future,"[40] optimism resulting from the robo-philic atmosphere (not only among leading roboticists) in Japan may affect such debate negatively. Because of this apparent lack of interest in the ELSI of care robots, Japan, a likely site of pilot projects in robotics, may fall into a "policy vacuum" situation, rendered vulnerable to adverse influences.

5. Conclusion

This study has sought to identify what is invented and what is discussed, to bridge the gap between invention and discussion, in an era when robots are increasingly used for communication in care settings. To examine the R&D trends of the field, I conducted keyword searches of the JPO database, alongside of a literature review of ethical discussions, using PubMed. The search revealed discrepancies of focus between invented products and ethics debates. Concerns about advanced AI or artificial moral agents, being futuristic, can hardly be the central issues in the current, emerging applications. On the other hand, some of the concerns in the literature that received less attention are already factual issues. Diverse purposes of robots can entail difficulty to preemptively know potential usages. Meanwhile, some robots evoke emotional responses from users, especially vulnerable people. In this regard, the significance of robots with animal-form or simplified human form could not be disregarded. Inventors chose exteriors of animal-form or simplified human form as a simple but effective way to meet their objectives. Such usages can entail intended deceptiveness, in that the robots are designed to provide some artificially produced reality in the absence of real human beings or animals, which can leave users in some way deserted. As robots with animal appearances are as common, robots in this category deserve special attention. As the existing regulation in Japan adopts an overly restrictive definition of "medical devices," the possible influences of communication robots on people's minds in care settings need to be monitored for unexpected usages of robots for diverse purposes. Beyond the looming concerns surrounding the "Frankenstein Complex" or the lack of concern resulting from unsubstantiated optimism, comprehensive precautions for the ELSI of communication robots, such as avoidance of unnecessary deception based on anthropomorphism or zoomorphism, need to be further elaborated and substantiated.

6. The limitation of the study

The study should extend to other databases both of academic articles and patent applications, including foreign patent offices. As the technology advances, the relationship between users and robots can change, which suggests the need to review anew the ELSI of communication robots.

Notes

1 Morozov, E. The Collingridge Dilemma. *Edge*. https://www.edge.org/response-detail/10898.

2 Ministry of Economy, Trade and Industry (METI) (2009). Academic roadmap in robotics in integrated humanities. http://www.ai-gakkai.or.jp/wp/wp-content/themes/shinra-of-the-sun/activity-pdf/rloadmap2.pdf.

3 Huschilt, J., Clune, L. (2012) The use of socially assistive robots for dementia care. *Journal of Gerontological Nursing*. Oct;38(10):15-9.

Broekens, J., Heerink, M., Rosendal, H. Assistive social robots in elderly care: a review. *Gerontechnology* 2009; 8(2):94-103.

Shibata, T., Wada, K., Ikeda, Y., Sabanovic, S. (2009) Cross-Cultural Studies on Subjective Evaluation of a Seal Robot. *Advanced Robotics*, 23(4). pp. 443-458.

4 Wallach, W. and Allen, C. (2009) *Moral Machines: Teaching Robots Right from Wrong* Oxford University Press.

5 Veruggio, G. The Birth of Roboethics (extended abstract). ICRA 2005, IEEE International Conference on Robotics and Automation, Workshop on Robo-Ethics (Barcelona, April 18, 2005).

The RoboEthics website (http://www.roboethics.org/) was last updated in 2011. The European Robotics Research Network (EURON) webpage is available at http://www.euron.org/activities/projects/roboethics.

6 Guizzo, E. World Robot Population Reaches 8.6 Million. April 14, 2010. http://spectrum.ieee.org/automaton/robotics/industrial-robots/041410-world-robot-population.

7 ISO. Robots and robotic devices. https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-2:v1:en.

8 Bekey, GA. Current Trends in Robotics; Technology and Ethics. in Lin, P., Abney K. and Bekey, GA. (eds)(2011) *Robot Ethics: The Ethical and Social Implications of Robotics*. MIT Press. p.17.

9 Ibid. p.18.

10 According to the ISO, the "ability to perform intended tasks based on current state and sensing, without human intervention."

11 The Intelligent Robotics Laboratory at Osaka University available at http://www.irl.sys.es.osaka-u.ac.jp/home/research.

12 An MHLW website on care robots http://www.mhlw.go.jp/file/05-Shingikai-12301000-Roukenkyoku-Soumuka/0000108000.pdf.

An MHLW website exemplifying care robots http://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000112870.html.

A Ministry of Economy, Trade and Industry (METI) website available at http://robotcare.jp/.

13 The description in this paragraph is based on the Japan Patent Office (ed.) (2008) *Sangyo zaisanken no genjo to kadai.* (Japan Institute of Invention and Innovation.

14 Lin, P. et al. (2011) Robot Ethics: Mapping the Issues for a Mechanized World, in Lin, P., Abney K. and Bekey, GA. (eds) *Robot Ethics: The Ethical and Social Implications of Robotics*. MIT Press.

Pearson, Y. and Borenstein, J. (2013) The intervention of robot caregivers and the cultivation of children's capability to play. *Sci Eng Ethics*. 2013 March;19(1):123-37.

Sharkey, N. and Sharkey, A. (2012) The Eldercare Factory. *Gerontology.* 2012;58(3):282-8.

Sharkey, N. and Sharkey, A. The Rights and Wrongs of Robot Care. In Lin, P., Abney K. and Bekey, GA. (eds) (2011) *Robot Ethics: The Ethical and Social Implications of Robotics.* MIT Press.

15 Veruggio, G. (2006). http://www.roboethics.org/atelier2006/docs/ROBOETHICS%20ROADMAP%20Rel2.1.1.pdf.

16 Shim, HB. Establishing a Korean Robot Ethics Charter.(2007) http://www.roboethics.org/icra2007/contributions/slides/Shim_icra%2007_ppt.pdf.

17 According to Martha Nussbaum, cited by Borenstein/Pearson p. 255.

18 Against Huschilt pp.15-16.

19 Saito, M. The status quo of Artificial Intelligence in progress. *Nikkei Business (Special Edition)*. January 2015. pp. 46-47.

20 The Future Expo (Miraiten) http://www.chusanren.or.jp/miraiten/report2015.pdf.

21 Kukita, M. (2009) The possibility of robot ethics. *Prospectus* (Kyoto University, Faculty of Letters), 11 http://hdl.handle.net/2433/71114 p. 2.

22 Abney K. Robotics, Ethical Theory, and Metaethics; A Guide for the Perplexed. in Lin, P., Abney K. and Bekey, GA. (eds)(2011) *Robot Ethics: The Ethical and Social Implications of Robotics*. MIT Press p. 50.

23 The world does not want Astro-Boy: The road to Japan's resurgence in robot industry. *Nikkei Business (Special Edition)*. January 2015 "The Realistic Future of Roboticized Societies" Nikkei Business (Special Edition). January 2015.

24 Borenstein, J., and Pearson, Y. Robot Caregivers: Ethical Issues across the Human Lifespan. In Lin, P., Abney, K. and Bekey, GA. (eds) (2011) *Robot Ethics: The Ethical and Social Implications of Robotics.* MIT Press p. 253.

25 Borenstein/Pearson. p. 254.

26 EURON Roboethics Roadmap refers to the precautionary principle (p. 12).

27 An article issued on August 4, 2014, in *AERA* (Asahi Shimbun Publications) reports hardships owners of canine robots experience, due to the end of support of AIBO by Sony Corporation.

28 Borenstein/Pearson. p. 254. Also, EURON Roboethics Roadmap. p.14.

29 Feil-Seifer, DJ. and Matarić, MJ. (2011) Ethical Principles for Socially Assistive Robotics. In *IEEE Robotics and Automation Magazine*, 18(1):pp. 24-31, March 2011. Special issue on Roboethics. Veruggio, G., Solis, J., and Van der Loos, M. (Eds.).

Newton, JP. (2008) Who needs friends…when robots may be the answer? Gerodontology 25(2) June 2008:pp. 65-66.

30 Ibid.

31 Ibid.

32 Ishiguro, H. (2012) *Humans, Art, and Androids – The reason why I create robots.* Nippon hyoronsha p. 129.

33 EURON Roboethics Roadmap. p. 11.

34 Arkin, R.C. Robot Ethics. From the battlefield to the bedroom: robots of the future raise ethical concerns. *Georgia Tech Research Horizons*. Winter/Spring 2007. pp. 14-15.

35 Huschilt. p.16.

36 Against Huschilt p. 16.

37 KASPAR the social robot. http://www.herts.ac.uk/kaspar

38 Sumioka, H. et al. (2013) Huggable communication medium decreases cortisol levels. Scientific Reports 3, Article number:3034.

39 EURON Roboethics Roadmap. p.8.

40 Sofge (2010) cited by Borenstein/Pearson p. 258.

All the online sources were accessed on August 31, 2016, unless otherwise specified.