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From Engineering Ethics to Robot Ethics

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From Engineering Ethics to Robot Ethics[1]

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1. Introduction

At the 2005 Aichi Expo, the presence of humanoid robots alongside Japanese booths attracted attention from visitors worldwide. The technology displayed in the form of brilliant two-legged ambulatory robots or robots that could make facial expressions identical to humans surprised many people.

Since then, however, Japan has fallen behind other developed countries in robot development. Why? One of the reasons for this would be the delay in examining the various ethical issues that one can expect in the social implementation of robots. As a result, the necessary rules for using robots have not progressed. If humanities researchers and science and engineering researchers can work together to stimulate ethical debate, it may encourage the birth of robotic products. This paper aims to provide some topics for collaboration.[2]

Section 2 verifies the validity of the framework of the existing field of engineering ethics by examining the safety of industrial robots. Section 3 investigates the trends related to robotic products' success in the advancing field of everyday life. Section 4 discusses the possibility that introducing robots into everyday life may give rise to ethical issues one did not previously question concerning industrial robots. Section 5 investigates the need to intensify the discussion on robot ethics to expand the future robotic product market.

2. Industrial Robots and Existing Engineering Ethics

Thus far, they have primarily manufactured robots for shouldering the "labour" of humans. As the

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[1] The original Japanese version of this article was published in *Society and Ethics* (*Shakai to Rinri*), No. 28 (Nanzan University, Institute of Social Ethics, 2013) with the title "Kougaku-rinri To Robot-rinri" . The autor made revisions to the original paper.

[2] When asked about the reason for the delay in the development of products such as the household vacuum cleaner "Roomba," a technician from Panasonic replied, "We have the technology" in a strong tone. However, regarding the reason for not commercializing it, he explained that "100% safety cannot be ensured." "For example, in case of accidents such as 'a cleaning robot collides with the family Buddhist altar and a candle falls, resulting in a fire,' '[a robot] falls down the stairs and collides with a person at the bottom,' or [a robot] moves into the path of a toddler who is walking and the baby falls down' the company will be held responsible for a major liability" [Abe, 2012]. If consumers are not willing to accept a cetain level of risk, the company fears that there might be serious liability issues, and it is therefore hesitant to market robotic products. In the future, in the case of the development of humanoid robots too, this problem might resurface. There is thus a need to reach a consensus between the manufacturer and the consumer about the risks and conveniences of robotics. Therefore, initiatiting a discussion about ethical issues related to robotics is essential.

word "robot," which is derived from the Czech word "*robota*" (forced labour),[3] suggests, robots were developed as labour machines. Furthermore, after World War II, amid the full-scale automation of industries worldwide, the role of industrial robots increased day by day. In the 1980s, Japan acquired a leading share worldwide in developing industrial robots, and it can be said that Japan was at the forefront of producing robots.

However, in the shadow of that spectacular advancement, numerous accidents occurred. The first human death by a robot on record occurred in Flat Rock, Michigan, in 1979, when a 25-year-old factory worker was killed in an accident at a Ford Motor Company plant. While the employee was gathering parts in a storage facility, a robot arm struck him in the head, killing him instantly [Kravets, 2010]. In the legal settlement that followed, it was found that safety features were missing, such as an alarm that sounded when the robot arm was nearby.

The first Japanese "Killer Robot" case to draw widespread attention occurred at a Kawasaki Heavy Industries Akashi plant in Hyogo Prefecture on July 4, 1981. A 37-year-old factory worker climbed over the intrusion prevention fence to check a malfunction with a robot and accidentally pressed a button that activated the powerful robot arm, which pushed him into mobile grinding gear equipment and killed him. "Entry Forbidden" was written on the fence, and a mechanism was established wherein the power supply would automatically stop if someone opened the wall at the time of protection inspection. This accident occurred despite established safety measures [The Deseret News, 1981] [The Economist, 2006].

What are the characteristics of industrial robots, and where do the dangers lie? Kodaira (2010) highlights the following three points: (1) robots are programmable; (2) robots are highly versatile due to their capability of making a broad range of movement; (3) uncertainty about the present situation can be addressed through instruction. The primary characteristics of industrial-use robots relate to their versatility. Through the use of a single robot, it is possible to make that Robot perform various tasks. Furthermore, because it is possible to change the programming of the action, the action settings can be fine-tuned to suit the actual installation, even when the Robot is performing the same work. Due to these characteristics, industrial robots are convenient; nevertheless, the fact that robots' movements are difficult to predict and understand ideally means that this is a source of risk. The form of their movements differs, depending on the situation, even with friendly robots.

Furthermore, it is typically necessary to "teach" robots how to perform their work. In such a case, humans must work near the Robot, but this is an inherently high-risk activity. The majority of human deaths by industrial-use robots have occurred while the human was working near a robot (1) while repairing breakdowns or (2) while performing a system start-up [Kodaira, 2010].

Preventive measures that can ultimately prevent accidents with industrial-use robots include "spatially isolating" robots, meaning that no one may enter a secure guarded area during automatic

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[3] Another origin is also said to be the word *robotnik* (worker) from the Slovak language (Cf. [Nishiyama., 2011]).

operation. Specifically, fences and other barriers are used to enclose a robot's range of motion. If these fences are opened, the power supply is cut, and the Robot ceases movement. In addition, "temporal isolation," or the practice of stopping machinery while humans are at work nearby, even outside the secure area, is an adequate safety precaution [Shiga, 2010].

While these isolation-based safety precautions are adequate, humans must come near robots when giving instruction and during maintenance inspections. The following safeguards have been adopted to prevent accidents in such cases.

1) Structure robots so that only those certified through education and training can approach them.
2) Structure robots such that no one can approach them unless they are put into a special mode that reduces their energy and speed.
3) Structure robots such that they can only move when the operator intentionally moves in a certain way, as with a teach pendant.
4) Structure robots are mechanically stopped when their moving parts exceed a certain speed.

Adopting these strategies when robots are designed can guarantee safety for humans who work close to robots [Mukaidono, 2009].

These safety measures realize the way of thinking within the existing field of engineering ethics, which values public safety, health, and welfare most highly.[4] And the design of industrial robots reflects this way of thinking to a considerable degree.

If robots advance into the domestic sphere in the coming years, we cannot keep them fenced up. If such progress is made, contact between humans and robots will become more frequent. Thus, devising new safety precautions has become necessary to avoid accidents. In recent studies, significant efforts have been made to instil "passive flexibility" in robots, meaning that when humans and robots come into contact, the existence of a mechanism for absorbing shocks will prevent accidents from becoming severe. To that end, it is essential to give the Robot some physical flexibility by using soft, pliable materials on its various joints and surfaces [Sugano, 2008].

These safety measures are already being applied in wearable robotics, quickly entering our lives. Sankai et al.'s group at Tsukuba University has started installing wearable "HAL" robots in rehabilitation centres [Nakajima, 2011]. When humans wear a robot to enhance their strength, one potential risk is "overburdened joints." Depending on the degree of this overburden, one can imagine injury to humans, resulting in broken bones, dislocations, bruises to muscles and tendons, inflammation, etc. To prevent such harm from occurring, HAL has mechanical safety features, such as (1) the adoption of an actuator whose maximum torque/angular velocity does not exceed the torque/angular velocity that the human body can tolerate; and (2) the installation of mechanical stoppers adjusts to the range that the human body allows. And it also has functional safety features

[4] Cf) ABET Code of Ethics, Fundamental Canon 1. ("Engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties"). http://sites.bsyse.wsu.edu/pitts/be120/Handouts/codes.htm

and output limitations on torque/angular velocity. In addition to these safeguards, the expertise that has been employed in the existing international safety certifications IEC60601-1 (Article 3), regarding medical equipment, and ISO10328 (Article 7), regarding artificial legs, has proven to be helpful [Sankai, Nabeshima, Kawamoto, 2011].

As described above, the safety measures developed for industrial robots and other areas will benefit the future of robot development. If considered in this sense, it is not too much to claim that existing ideologies of engineering ethics will continue to play an essential role in robot development on the shop floor.

3. Development of Robot Engineering with an Eye on 2050

How will robot engineering, which began in industrial robot development, develop in the future? The *Technological Strategy Report on Creating a Robot Society in the 21st Century*, issued in 2001 by the Japan Robot Association, estimated that the market for robots would extend into the lifestyle, health and welfare, public safety (disasters, etc.), biotech, and manufacturing sectors, becoming an $80 billion industry by 2025. It was predicted that approximately half of that figure would be monopolized by robotic products for the "domestic sphere." Compared to the current reality, the robot market has not expanded as smoothly as predicted. Still, this prediction was made immediately after the beginning of the 21st century, and a large amount of the national budget has been invested accordingly. In other words, although examples of the development of actual products remain rare, the efforts have sped up the development of robot technologies capable of operating in the domestic sphere at the level of basic research at the start of this century.

In 2007, the Japan Robot Association created an academic roadmap for engineering fields with an eye toward society in 2050. The social issues discussed in this document that cannot be ignored include (1) the decreasing birthrate and the increasing ageing population: the population of young workers is decreasing at the same time as it is proving difficult to support a large proportion of the elderly population; (2) energy problems: petroleum resources are being exhausted, and low-consumption/high-efficiency equipment must be designed; and (3) environmental problems: global warming and carbon dioxide emissions must be reduced. Furthermore, three concepts—comfort (C), safety (S), and green (G)—were proposed as common ideals (CSG) to help solve these problems. Because robotics is primarily involved with (C), it is expected to fulfil an essential role in assisting Japan to adapt to the problems caused by a decreasing birthrate and an ageing population [Uchiyama, Kaneko, Kunii, 2008].

Under these circumstances, the Robotics Society of Japan, the Japanese Society for Artificial Intelligence, and the Japan Ergonomics Society have collaborated to create an academic roadmap in the field of robotics on commission from the Ministry of Economy, Trade and Industry (METI). "Robot Challenge 30" was presented as the theme.[5] The report's contents reflect the technological

[5] The report can be read at the site of the Japanese Society for Artificial Intelligence. http://www.ai-gakkai.or.jp/about-us/activity/rloadmap/ (accessed 8/25/2022).

developments that active robotics engineers aim for. This roadmap is organized around three themes drawn from the past 100 years of robotics history: (1) social systems and robotic intelligence; (2) systems for helping people; and (3) human and machine integration (human expansion). In other words, it paints a vision of the next 50 years in which we will see that robots increasingly approximate the human form, eventually merging with humans altogether. Naturally, in this trend, it has been pointed out that it is necessary to consider the perspective of "robot ethics" on how to build relationships between humans and robots. And there is also a need to discuss "cyborg ethics" [Sato, Mizoguchi, Tomita, Uchiyama, 2008].

Turning our attention to the 30 Robot Challenges, we find the following:

- ◆ Challenge 9 – self-reference, evaluation, and repair systems: the development of "meta-cognitive" functions, that is, the awareness, interpretation, and evaluation of the contents of one's cognition, condition, and behaviour, and based on this, the ability to revise and repair oneself, maintaining consistency, lawfulness, and homeostasis
- ◆ Challenge 11 – cognitive development systems: the elucidation and realization of systems capable of improving their cognitive ability and achievement while interacting with each other and the outside world
- ◆ Challenge 13 – the emergence and understanding of others' goals and intentions: the ability to understand the intents and purposes of others is dependent upon the ability to understand the meaning of others' actions and to make independent judgments about behaviour in service of humans
- ◆ Challenge 15 – autonomy: the ability to act by oneself without external commands and rules. We will realize the development of the power to decide what to do and work with self-discipline, having all of "understanding of the meaning of information", "recognition of importance", "emergence and understanding of purpose/intention", and "self-reference/evaluation/restoration."
- ◆ Challenge 21 – BCI/BMI/Cyborg: direct integration of the human brain and computer or machine as an interface between humans and robots to allow more flexible interaction. Furthermore, by directly integrating humans and machines, human abilities will not only be supplemented but also expanded
- ◆ Challenge 23 – robots for community building: development of robots to support the revitalization and maintenance of community and assist in the formation of the community by bringing people together through some commonality
- ◆ Challenge 30 – intelligent space: development of technologies capable of understanding intentional behaviour from the use of all goods used in one's daily living space, grasping social movements, and helping people and society

Such technologies are an index that reflects trends over 50 years, including many that are still quite far from realization. However, it can be said that such a trend creates the possibility that our society will slowly change in the direction of the movement, whether or not it will be realized in 50 years.

Now, if researchers are aiming at the technologies considered above, can we say that there will be no problems bringing them about as long as mere “safety” can be assured? The values expressed in the existing engineering ethics framework emphasize public safety and the protection of health and well-being. Based on this expertise, ensuring safety should be considered a matter of course in robot development. However, the possibility exists that various ethical problems that do not fit into this framework will arise from robot development. Therefore, let us next turn our attention to these.

4. New Ethical Problems Raised by Robot Engineering

European robot engineers were the first to examine the impact of robot engineering on society. Inspired by the Pugwash Conferences, the first international conference on robot ethics was convened in 2004 by Gianmarco Veruggio, an Italian researcher at the Scuola di Robotica in Genoa.[6,7] A chronological list of meetings on robot ethics that have been conducted at his initiative is as follows:[8]

1. First International Symposium on Roboethics Sanremo, Italy, January 30–31, 2004
2. Fukuoka World Robot Declaration, Fukuoka, Japan, February 25, 2004
3. IEEE-RAS established a Technical Committee (TC) on Robo-Ethics, 2004
4. ICRA 2005 Workshop on Roboethics, Barcelona, Spain, April 18, 2005
5. Italy-Japan 2005 Workshop “The Man and the Robot: Italian and Japanese approaches”, Waseda, Tokyo, Japan, September 7–8, 2005
6. EURON Atelier on Roboethics, Genoa, Italy, February 27–March 3, 2006
7. ICRA 2007 Workshop on Roboethics, Rome, Italy, April 14, 2007
8. ECAP07 track “Philosophy and Ethics of Robotics”, Twente, The Netherlands, June 21–23, 2007
9. International Symposium “Robotics: New Science,” Accademia di Lincei, Rome, February 20, 2008
10. ICRA 2009 Workshop on Roboethics, Rome, Italy, April 17, 2009.
11. SPT2009 Track “Robots, cyborgs and artificial life,” University of Twente, the Netherlands, July 8–10, 2009
12. ICRA 2011 Fourth Workshop on Roboethics, Shanghai, China, May 13, 2011

Themes explored in these early discussions include (1) sociocultural diversity concerning robot acceptance; (2) privacy: disclosure and unauthorized use of personal information; (3) robotics and labour: the impact of revolutionary technological innovations on employment; (4) robots and national defence: the ethical meaning of “killing machines” and machines as accessories to murder; (5) entertainment robots: robotic pets and the issues raised by individual control over emotional consumer robots; (6) ubiquitous computing: omnipresent robots; (7) bio-robotics; (8) sex and robotics: robot partner; (9) religion and intelligent machines; (10) robots as intellectual

[6] The English title is The Institute of Intelligent Systems for Automation in Genoa.

[7] Pugwash conference: An international conference convened in 1957 by scientists seeking the abolition of nuclear weapons.

[8] Refer to the Official Roboethics Website, www.roboethics.org (accessed 8/25/2022).

beings: problem of robot rights, robotic slavery in society; (11) responsibilities of the profession; and (12) social responsibility for harm, personal and corporate accountability, and legal liability.

The above are topics about robots that have not yet been realized; some may view them as an extension of science fiction. Should the discussion of as-yet-unrealized technologies be considered unproductive? Numerous theorists have criticized the extant literature on engineering ethics regarding this point. In an overview discussing responsibility, the Dutch legal philosopher Bovens divides the concept into passive responsibility and active responsibility. The former refers to the responsibility of responding to the past-oriented question, mainly "Why did you do that?" after an accident or incident. Conversely, the latter is a way of responding positively to what is to come, implying a responsibility primarily to answer the future-oriented question, "What should be done?" [Bovens, 1998, p.27]. Van de Poel, a Dutch science and technology studies (STS) theorist, and Verbeek, a Dutch philosopher of technology, have indicated that engineering ethics has been biased toward the passive form of responsibility [Van de Poel & Verbeek, 2006].

In other words, in existing engineering ethics, the crucial point is to learn from accidents that have occurred in the past. Engineers are responsible for quickly sounding the alarm when they notice that society is being exposed to dangers created by technology [Verbeek, 2011, p.4]. Indeed, Verbeek et al. do not dismiss the passive form of responsibility outright but claim that it alone is insufficient. They argue that in thinking about the ethics of technology, one must consider a future-oriented form of active responsibility. Specifically, by introducing the concept of "design ethics" when designing artefacts and evaluating how the artefacts will affect our daily lives, they say that we should decide the designs of artefacts in advance to improve our quality of life (QOL) in the context of life. Furthermore, Verbeek (2011) posits that artefacts should be conceived to guide us toward ethical behaviour.

The general idea of design ethics applies to the design of all artefacts; however, this way of thinking has become especially necessary in producing robots. There is no denying that when robots begin to appear in society, their presence will impact social life. For example, with a robotic pet or friend, a possibility exists that it might intervene in our emotional lives. The design of robots that play such roles will have to consider not only their physical impact on humans but also their psychological impact. In this case, it is essential to study the types of physical appearances, gestures, and facial expressions that give humans a sense of security and then employ them in the design. In addition, if humanoid robots that are being developed by so many Japanese roboticists begin to be introduced into society, then examining the sort of impact of the use of such robots on human relations will be essential.[9] For example, a recent study has confirmed that human infants will

[9] Honda debuted a bipedal humanoid robot, "ASIMO," in 2000. Following this, many companies, such as Sony, Toyota Motor Corporation, and Victor Company of Japan, announced humanoid prototypes. However, none of these technologies has been commercialized as of yet. Among roboticists, many have criticized the humanoid form as being inefficient. For example, Colin Angle of iRobot, the company that developed the "Roomba" cleaning robot, imagines groups of specialized robots providing support for various household chores, instead of a single, general-purpose humanoid robot that manages the home (cf. [Ito, 2005] [The Economist, 2006]).

actively follow the gaze of a humanoid robot [Meltzoff, Brooks, Shon, & Rao, 2010]. Human infants follow the eye of their parents and focus on the same things as their parents to learn the roles played by things that appear in their life and to understand their positions. If robots become part of daily life as social actors, the chances are high that they will then become models for the next generation. In other words, children might be able to learn from robots. If that becomes the case, robot engineers will no longer be considered designers of simple machines but engineers of social actors whose behaviour will be the model for the next generation. Until today, it has not been necessary to consider such issues in the design of artefacts.

Already a concern in this context is how the introduction of babysitter robots will affect children's development. Artificial nursery experiments with rhesus monkeys produced significant social dysfunction compared to monkeys raised by birth mothers. It will be necessary to regulate or make robots learn the code of ethics of babysitting and the human rights code of children. [Sharkey, 2008].

As described above, it is essential in robot design to adopt design ethics that considers social effects. This approach must have the same degree of importance as the guarantee of safety has had in the past.

Make no mistake: the problem of what behaviour to instil in robots and just how powerful to make them are at the center of the ethical challenges raised by robots. However, this focus alone is insufficient. Our behaviour toward robots will also likely be a problem. For example, Ron Arkin of the Georgia Institute of Technology asks whether we will still sound persuasive while kicking a robot dog when we tell our children, "You mustn't kick (real) dogs!" [The Economist, 2006]. This concern is all the more applicable to humanoid robots. It is not hard to imagine that the creation of a social environment in which the abuse of humanoid robots is common would soon affect how humans treat one another. Thus, examining the type of relationships we want to have with robots when they are introduced is essential [Chatila, 2011].

Henrik Christensen of Sweden's Royal Institute of Technology has argued that "safety, security, and sex" are important matters of concern. He has argued that because there are already humans who try to have sex with blow-up dolls, it should not come as a surprise when humans begin to have sexual relations with robots in the future.[10] In this case, should the sale of sex dolls in the shape of children be legally allowed? While the possibility exists that the use of such dolls by those with a propensity for sexually abusing children could be called "therapy," it is pretty likely that many will criticize the notion that such products merely fulfil innocent fantasies. These social problems could arise with the development of humanoid robots [The Economist, 2006].

If robots come to have sensation, judgment, and the ability to behave autonomously, they could cause complex problems in direct proportion to their degree of autonomy. They could contain actual cases of robots causing harm to people. If such incidents occur, would the legal system, as it has existed until now, be able to issue judgments on such cases? Is it possible to force robots to acknowledge their criminal responsibility and atone for their sins? If this cannot be done, then it is

[10] Regarding this issue, please see the detailed discussion in Rena Saijo's essay in this special issue.

unclear where the blame would lie: should it be with the designer, the manufacturer, the seller, the supervisor, or perhaps the individual who instructed the Robot as a social actor in the ways of polite society?[11] Therefore, introducing robots into society could be hazardous if this decision cannot be examined and a social consensus achieved before an accident occurs. In addition, some observers have argued that introducing "robot insurance" against the risk of injury and damages to users must also be examined [Yamada, 2008].

An example of social risk is the possibility that robots, which were initially developed to cope with the declining birthrate and ageing population, will take on the jobs of human beings. It would therefore be necessary to incorporate laid-off workers into other fields in anticipation of expected job losses. If this cannot be done, the use of robots might negatively impact the economic environment [Oeki, 2008]. Moreover, others have contended that engineers should be actively involved in creating business plans to prevent the misuse of robot engineering by the military. Sankai (2011) of Tsukuba University argues that instead of being a "for-profit business," robot engineering should be a "social business" that works to support society and improve social welfare.

Numerous other issues also deserve to be examined; however, they cannot all be considered here due to space constraints. Thus, the last matter we will discuss is what will be necessary for engineering ethics that seriously consider Verbeek's concept of active responsibility. He claims that it is insufficient to consider only safety in the design of artefacts and that one must consider, beforehand, the various impacts of these artefacts on society and investigate designs that will prevent accidents. This concept of "design ethics" becomes especially important in fields of robot engineering that are expected to impact the community significantly.

Furthermore, fostering debates on the ethical issues related to individuals who use robots is essential to facilitate the acceptance of robot technologies in society. Because there is a high probability that robot-human relations will be reflected in human-human relationships, this raises the question of whether we can treat robots like other "mere objects" with which we are familiar in daily life. There needs to be a discussion concerning the relationship between humans and robots that includes the fundamental question of whether robots should be subject to moral considerations in society.

In addition, the ethics of raising robots as social actors must be considered once they have acquired a high level of autonomy and the ability to learn. Moreover, developing a fixed moral perspective on robots before they are introduced into society is essential if they are to engage in smooth social relationships with humans.

In sum, the process of societal acceptance of robotic technologies requires an examination of (1) ethical principles that should be built into robots; (2) the ethics of robot manufacturers; (3) the ethics of robot users (and consumers); and (4) the ethics of robot teachers. Thus, a new framework is required that integrates all of these into "robot ethics."

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[11] The concept of "the responsibility of robot educators" comes from Prof. Uesugi Shigeru (Faculty of Science and Engineering, Waseda University).

5. Promotion of the Robot Industry and a Robot Ethics Charter

Kukita (2009) clarifies what the word "robot ethics" means to different people. According to him, the term "robot ethics" implies all of the following:

1) the ethics of manufacturing robots: the ethics of robot engineers
2) the ethics that robots should obey: the ethics of robots themselves
3) ethics about robots: consumer ethics.

In addition to these aspects,

4) the ethics of educating robots: robot trainer ethics

should be added.

Future debates on these areas of robot ethics should not be limited solely to the research community. Researchers, manufacturers, and citizens (consumers) must be included in these discussions. Let us consider the reasons for this.

To expand the market for robotic products, "many users of the same quality" must seek access to it.[12] However, it is exceedingly difficult to facilitate this in a short period. To achieve success rapidly, as occurred in the automotive field and which took nearly 100 years, quickly developing a social consensus on various issues related to robotic products is necessary [Tanie, 2004].

Article 1

Humans should not use robots if the human-robot labor system is incompatible with the highest legal and technical standards for ethics and safety.

Article 2

Robots must perform roles corresponding to their form and always respond to humans.

Article 3

Robots should be given adequate autonomy to defend their own existence in accordance with their conditions, as long as their self-defense does not cause them to violate the first two articles and management can be smoothly transferred to another subject.

Table 1. Beyond Asimov's Three Laws

[12] Tanie's terminology can be interpreted to mean that the circulation of a certain product depends on a group of consumers sharing clearly defined knowledge about a product. If the belief in the safety and convenience of a given product cannot be fostered among a large group of consumers, consumption will lag behind production and the industry's profits will falter. In areas where a market already exists, it is perfectly acceptable for engineers to improve product performance; however, because a market for robotic products does not yet exist, any number of product performance improvements will not necessarily lead to commercialization (Tanie, 2004: 10–11).

To promote robotics, we must develop new products and consumers simultaneously, and a "Robot Ethics Charter" will also be required here. The content of the Robot Ethics Charter must reflect the overall discussion of robot ethics, particularly the guidelines that provide specific guidelines regarding the ethical elements that robots should protect, how to manufacture robots, and how to interact with robots. In addition to these elements, aspects of commitments to be shared between researchers, manufacturers, and consumers are essential. Publishing such a document and updating it from time to time will help deepen the debate on ethical issues related to robotics technology and reach a consensus on how to address them.

Article 1 (Objective) The objective of the robot ethics charter is to affirm an anthropocentric ethical model that ensures the coexistence and coprosperity of humans and robots.
Article 2 (Principle of Cooperation between Humans and Robots) Humans and robots should protect the sanctity of each other's lives, information, and robotic ethics.
Article 3 (Human ethics) When manufacturing and using robots, humans always have to decide how to judge right and wrong.
Article 4 (Robot ethics) Robots, as friends, assistants, and partners to humans must always obediently follow their orders and never harm a human.
Article 5 (Manufacturer ethics) Robot manufacturers must create robots that can be recycled, are obligated to protect information, and respect the sanctity of human life.
Article 6 (User ethics) Robot users should respect robots as they would a human friend and should not abuse them nor illegally modify them.
Article 7 (Implementation agreement) The government and local authorities must implement effective steps to realize the spirit of the charter.
South Korean Ministry of Trade, Industry, and Energy (MOTIE)
August 29, 2007

Table 2. Draft of the Korean Robot Ethics Charter

The METI's "Guidelines for Guaranteeing Next Generation Robot Safety" (2007) already exists as a guide of ethics for robot manufacturing.[13] These guidelines emphasize the maintenance of safety

[13] Let us introduce a portion of the contents here.
Guidelines for ensuring safety in next-generation robots
http://www.meti.go.jp/policy/mono_info_service/Mono/robot/PDF/guideline.PDF (accessed 8/25/2022)
2.3 Implementation of safety measures by manufacturers
2.3.1 Safety measures to reduce the risk of next-generation robots introduced by manufacturers should be implemented in the following order:
(1) Make safety an essential part of the design.
(2) For risks that cannot be reduced to an acceptable degree by inherently safe design, safety protection and additional protection measures are required.
(3) As for risks that cannot be reduced to an acceptable degree by inherently safe design, safety protections, or additional protective measures, information regarding management, sales, and use must be provided to managers, sellers, and users.
2.3.2 When manufacturers undertake safety measures, they must take care not to create new sources of danger, hazardous situations, or increase the level of risk.

but mention the social aspects related to the design of robots. The guidelines were also produced for the benefit of manufacturers and did not reference consumers' attitudes.

The three principles for robot engineering discussed in Asimov's science fiction novel *I, Robot,* are pretty famous as ethical principles that robots should follow.[14] Asimov created these principles assuming that robots can become moral actors, but some individuals perceive a great danger in giving robots a strong sense of autonomy. To clarify their position that final responsibility should always lie with a human, they have proposed three principles of their own (Table 1) [Murphy Woods, 2009].

Korea, aiming to have robotic products installed in every home by 2020, formulated a robot ethics charter in 2007. They have only released a draft, but from the contents, one can see that they are significantly focusing on the ethical balance between producer, consumer, and the Robot (Table 2).[15] One might expect that formulating this code of ethics will generate a nationwide debate. There is no way to measure the extent to which Korea's Robot Charter can be considered a success except to judge it after it has developed; however, efforts like this have great significance as processes for introducing the latest technologies into society.

In Japan, the time has come to create an environment where citizens can actively judge whether to allow the introduction of the fruits of the progress in robotics into society. As robotic technologies diffuse into society, procedures for creating a social consensus among roboticists, manufacturers, and citizens (consumers) on the relevant ethical issues will be required. Specifically, it would be adequate to create a Japanese version of a robot ethics charter that provides a platform for these three parties to debate the issues. Researchers have already begun taking adequate measures; however, no steps have been taken to incorporate public opinion.[16] The authors of this paper are part of a research group that

2. 5 Record of risk reduction measures (documentation)
Manufacturers must record steps taken to reduce the risks posed by next-generation robots based on the contents of safety precautions implemented according to these guidelines and the results of risk assessments of next-generation robot manufacturing.
2.6 Next-generation robot risk management system and maintenance
2.6.1 When critical failures on safety and injuries caused by next-generation robots occur, manufacturers must promptly set up a system capable of appropriately responding by expanding injury prevention measures.
2.6.2 When critical failures on safety and injuries caused by next-generation robots occur, manufacturers must record details of the accident, the injury, and response.

[14] The Three Laws of Robotics (Asimov, 2004)
The First Law – A robot may not injure a human being or, through inaction, allow a human being to come to harm.
The Second Law – A robot must obey the orders given it by human beings, except where such orders would conflict with the First Law.
The Third Law – A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

[15] Reference: https://en.wikipedia.org/wiki/Three_Laws_of_Robotics (Accessed: 8/16/2022)

[16] Regarding domestic initiatives, Chiba University deserves a special mention for their involvement with the formulation of the robot charter. Using Asimov's Three Laws as a foundation, they came up with a unique position.
Chiba University Robot Charter (2007) http://www.chiba-u.ac.jp/others/topics/article2007/20071127.html (accessed 5/25/2013)
Article 1 (code of conduct)

works with robot engineers to develop a robot ethics charter sometime in the future.[17]

6. Conclusion

In this paper, we examined the effectiveness of existing engineering ethics considering current developments in robotics. Of course, the emphasis on safety in engineering ethics as it exists now is necessary for robot engineering. However, the ethical problems raised by the products that will come from robot engineering soon are not likely to be fully addressed by merely guaranteeing safety. If the market for robotic products expands, then a process for developing a social consensus among roboticists, manufacturers, and citizens (consumers) regarding the various ethical problems raised by robotics will be necessary. Furthermore, a forum for debates between experts and citizens must be created to achieve this consensus. In addition, a tentative plan for starting these debates is also necessary. We argue that the time has come for Japan to begin making an effort toward establishing a robot ethics charter.

This charter is intended to provide ethical prescriptions for all those involved in robot education, research, and development at Chiba University.
Article 2 (human livelihood)
Everyone involved in robot education, research, and development at Chiba University must conduct their education, research, and development for peaceful purposes and the benefit of human livelihood.
Article 3 (prevention of unethical use)
Robot educators, researchers, and developers at Chiba University are integrating measures into robots to prevent their unethical and illegal use.
Article 4 (contribution of educators, researchers, and developers)
Robot educators, researchers, and developers at Chiba University shall comply not only with Asimov's Three Laws but also with all of the articles of this charter.
Article 5 (permanent compliance)
Robot educators, researchers, and developers at Chiba University Pledge to respect and protect the spirit of this charter even when off-campus.

[17] The Philosophy of Robot Applications Research Group (Minao Kukita, Nobutsugu Kanzaki, Masahiko Igashira, Shinya Oie, Shinpei Okamoto, Rena Saijo, Kojiro Honda), 2013 Academic Research Assistance Grant-in-aid Selection, Basic Research (C) Subject Number 25370033, Subject Title: "Creation of Ethics for Robots based on Engineering Concerns" (Research representative: Kojiro Honda).

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