Life or Death by Robot?

To enable the design of moral robots, it is first necessary to define human and robot morality, then to implement awareness in robots.

By Kimberly Stowers, Kevin Leyva, Gabriella M. Hancock, & Peter A. Hancock

FEATURE AT A GLANCE:
Although robots are becoming widely known as aids to human success, they are likewise gaining reputations as tools of death. This begs the question of whether robots can be morally programmed. We address this question through discussion of various conceptualizations of robots in society. Using case studies, we highlight the irony of robots functioning both as heroic and hazardous agents. We conclude by assessing whether morality can be designed in robots and present guidelines for designers to attempt such a feat.

KEYWORDS:
robot ethics, morality, AIBO, ASIMO, da Vinci Surgical System, artificial intelligence, service robot, human-robot interaction, robot self-awareness, DARPA Robot Challenge

On October 24, 2012, the Defense Advanced Research Projects Agency (DARPA) initiated a specific humanitarian-oriented effort by funding the development of robots to provide disaster relief in environments that are deemed too dangerous for humans to operate in (DARPA, 2014). Yet, on that same day, an innocent Pakistani woman by the name of Momina Bibi was killed by a drone strike while working in her garden in Waziristan (Amnesty International, 2013; McVeigh, 2013). We think it is reasonable to inquire whether the latter robotic drone strike created an environment that was dangerous for human occupation. Transparently, this environment was too dangerous for Momina Bibi.

The development of robots that can operate in dangerous environments promises to bring appreciable improvements to human life and relief in times of need. Yet these human innovations have also clearly brought pain, suffering, and death. With the latter antithetical outcomes, there emerges the question as to whether robots themselves can be morally programmed to meet the needs of all human beings or whether there will always be a necessary conflict between the constructive and destructive forces so embodied by autonomous entities.

In addressing this concern, we must address many foundational premises concerning human interaction with and use of technology. For example, no unequivocal or precise boundary conditions exist for what connotes a robot in the first place. Having defined robots, how does one envision that society will continue to employ them? Will an autonomous robot that is designed to save people also necessarily possess the power to destroy them?

To begin, we briefly analyze the definition of robots, articulating the current conceptualizations to identify potential future developments. We then survey case stories of heroic and hazardous events involving robots and humans together. These narratives highlight the contradictory possibilities of prospective robots as helpful and/or harmful and humans' role in determining their use. We then discuss the fundamental question underlying our discourse: Can morality be programmed – that is, designed – into robots? We also examine whether this latter effort is vital to the survival of humankind with the rise in weapon systems that may eventually be turned on their creators. We conclude with suggestions regarding such design principles for nascent morality in robots.

WHAT IS A ROBOT?

The term *robot* was first used during the Habsburg monarchy of the Austro-Hungarian Empire in the 1800s. At that time, the term referred to a labor rent that tied peasants to the farmland of some local landowners (Taylor, 1948). It was popularized in its more modern form in Capek's 1921 play *Rossum's Universal Robots*, in which robots were depicted as artificial humans (Long, 2011). Since then, the term *robot* has continued to evolve in both scientific and popular conceptions (see Schaefer et al., 2014).

Dictionaries today define robots as operated machines capable of carrying out complex tasks ("Robot," 2015). This definition encompasses a broad range of entities, such as assembly machines; humanoids, such as ASIMO (see Figure 1; Honda, 2015); and animal surrogates, such as AIBO (see Figure 2; Sony, 2015). This general definition of robots can also include artificial intelligence (AI), which involves machines smart enough to emulate human behavior (see Fulcher, 2006). Robots today are gravitating toward such intelligence, often operating without

Figure 1. ASIMO, the humanoid robot by Honda (2015).

immediate human control. This development opens many opportunities for the use of robots in the future. The International Federation of Robotics (IFR; 2015) has indicated that the use of service robots will increase, most notably in military defense, which relies heavily on the use of intelligence (see Figure 3; IFR, 2015). Seeing the functions that robots could serve in the future of defense may mitigate or aggravate a sense of "robophobia," or fear of robots (see Schaefer et al., 2014).

ROBOTS: HERO OR HAZARD?

Robots are often involved in acts that would be considered heroic if done by humans. Robots have acted as essential tools in completing dangerous military missions and have occasionally been called on to sacrifice themselves in order to protect humans. A notable example concerns explosive ordnance disposal, whereby technicians send robots (see Figure 4; iRobot, 2015) to inspect and diffuse bombs. Technicians know that if the bomb detonates, they will lose a piece of equipment instead of a soldier (Brennan, 2014).

Robots have also helped to save many lives in disaster relief and the medical domain. For example, the da Vinci Surgical System (see Figure 5; da Vinci Surgical System, 2015) has been involved in more than 1.5 million surgical procedures, including one of the present authors (da Vinci, 2012).

However, beneficial robots do not always change things for the better. Robots designed for heroic efforts can be used for destructive efforts – whether intentionally or accidentally. Occasionally, complications with seemingly harmless robotic

Figure 2. AIBO, the animal surrogate by Sony (2015).

operations arise, resulting in injury and death (Cooper, Ibrahim, Lyu, & Makary, 2013). The same da Vinci robot that has saved so many lives has destroyed some as well, calling into question the safety of its use (Associated Press, 2013). Robots developed for emergency use are now feared for their potentially lethal use (Davenport, 2015). What is being celebrated as a symbol of heroism in one moment may then be feared as the harbinger of death the next.

Death by robot is not a new phenomenon. The first recorded incident of a fatality via robot occurred in 1979 and involved Robert Williams (Kravets, 2010), who was hit in the head and killed by a heavy-duty robotic arm. A similar incident killed Kenji Urada in 1981 when he was crushed by a robotic arm as he was repairing it (Deseret, 1981; Hamilton & Hancock, 1986); and a Volkswagen employee was killed in 2015 when he was grabbed and crushed by a robotic machine (Dockterman, 2015). Other deaths are results of military conflicts. The aforementioned death of Momina Bibi is hardly an isolated incident, as drones have become widely used in the battlefield (Sharkey, 2011; International Human Rights and Conflict Resolution Clinic & Global Justice Clinic, 2012).

Adding to the concern over robot-inflicted death is the increasingly dynamic use of AI in robots. Most of the examples we have shared include some form of rudimentary AI. Today people rely on autonomous systems to carry out activities that require more intelligence. Such activities may be dangerous, causing many leading scientists to question the safety of allowing robots – especially destructive ones – to become too intelligent without careful oversight. This concern has resulted in an open letter proposing the ban of autonomous weapons that are outside of human control (Future of Life Institute [FLI], 2015).

At this turning point in history, humans are responsible for deciding on and implementing the use of robots, and it is up to us to determine their design. In doing so, one must consider

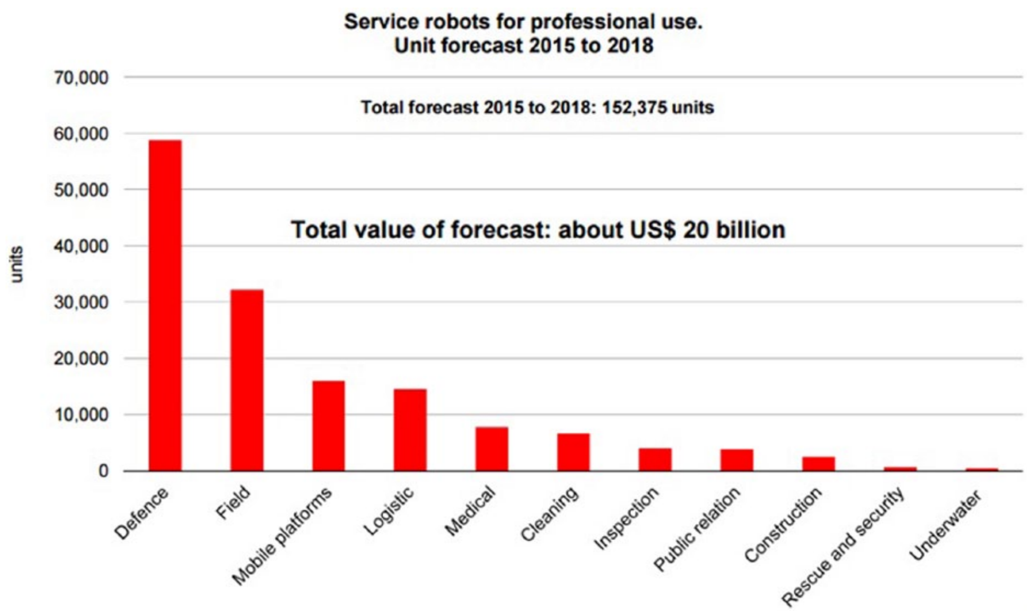

Figure 3. Anticipated use of service robots from 2015 to 2018 (International Federation of Robotics, 2015).

Figure 4. The iRobot 510 PackBot® for explosive ordnance disposal (iRobot, 2015).

Figure 5. An example of a da Vinci Surgical System (da Vinci Surgical System, 2015).

the moral and ethical processes involved, including whether morals can be designed into robots.

DESIGNING MORAL ROBOTS

Can robots be designed to reap maximum benefit and inflict minimal harm? What bounds and constraints may be imposed on their design? Asimov proposed three such laws in his 1942 short story "Runaround," later included in his book *I, Robot* (Asimov, 1950): (a) A robot may not cause or allow harm to a human, (b) a robot must obey orders given by its operator unless the orders conflict with the first law, and (c) a robot must protect its own existence unless doing so conflicts with the first or second law (see Murphy & Woods, 2009). Later, Asimov added a fourth law contending that robots may not harm humanity. Although these laws are merely objects of science fiction, they are important to consider in light of the use of robots today, as it is now commonplace to find robots causing extensive harm.

Indeed, given today's use of robots, it is becoming necessary to implement laws that take into account the possibility that some robots are designed to kill. Such an effort has been considered, with suggestions that robots used in warfare should be treated as soldiers and bound by international humanitarian law

(Arkin, 2009b, 2013). Yet, in order for robots to be bound by these laws, they must have a foundation for acting on the basis of the moral laws in the first place.

A crucial question then becomes whether it is possible to hard-code morality. Robots looking to kill humans are fulfilling an autonomous directive for murder. They are reflecting the moral code expressed as the intention of their designers. Such moral programming allows an exception for killing humans when the killing is for a perceived "greater good." In this sense, morality is an a priori determination of the entity creating that original robot design. Thus, it is up to the human creators to program morality into the robot.

It has been argued that morality can be programmed into robots according to theories that guide the simple decision "What do I do now?" by examining how desirable or moral certain actions are (Gips, 1995). This approach to "moral programming" is not a new idea. In 1933, Birkhoff created a formula for representing ethics in robots, but with the advanced state of intelligence in robots today, we wonder if an algorithmic approach to ethics is enough to ensure the moral use of robots (Birkhoff, 1933). Although the design of robots should ultimately be based in ethical law and practice, we argue that such ethics merely provide the building blocks by which moral robots can be designed.

Yet, a machine may not be able to exercise self-determined morality without some degree of conscious emotion (Arkin, 2011). For the most part, robots do what they are designed to do. This constraint restricts robots such that programmed morality is limited to the complex set of code being followed. The ability to not harm humans is not a simple law but demands interpretation of the environment, comparison of information with software commands, and decisions based on algorithms.

Although these concerns have been explored, there remains much to be done to achieve morality (Arkin, 2009a). For example, how can the current state of the science in programming robots be enhanced such that complex code includes consciousness and emotion? It is necessary to consider these qualities in the programming of morality. Yet, such research remains limited.

A second issue in the moral programming of robots is how it affects morality in humans. The same way humans impose their morality on machines, they are affected by the assignment of morality to machines. In order to allay their own guilt in making difficult moral decisions, operators can distance themselves from such decisions, invoking the actions of the robot as the culpable entity. This behavior has been seen in the practice of capital punishment, one of the most difficult ethical issues facing society. Capital punishment has been conducted via a variety of methods, including electrocution, hanging, gas chambers, firing squads, and guillotines.

The system of execution that was first intended to dissociate blame on behalf of the executioner(s) via technological means was the firing squad, consisting of a cadre of armed law enforcement officials. To allay guilt on behalf of the squad, one member was given a blank cartridge at random so that none would know who fired the fatal shot (Carver, 1998). When lethal injection was adopted in the 1970s, this trend of diluting personal responsibility for another human's death continued via technological intervention. The typical lethal injection process includes releasing a combination of drugs into the bloodstream, some of which lead to death. The protocol to achieve this result consists of two stations staffed by personnel who are not aware which station contains the lethal drugs.

The moral ambiguity involved in capital punishment is so contentious that even those whom people elect to be their legal (if not ethical) judges have never agreed on the validity of the procedure (Mears, 2008), leaving one to wonder how much humans lack understanding of their own morality. Yet, in the case of assigning morality to machines, people think it is equally important to justify and codify human morality.

A final critical issue that arises concerning ethical robot design and behavior is the question, "Whose ethics?" Clearly, we have approached the issue here largely from a Western perspective, but we must immediately acknowledge that differing cultures embody different ethical structures and imperatives. Moral codes are human creations, and as such, they vary by the way each society chooses to organize itself. Such principles that appear self-evident and are promulgated by one group do not necessarily apply to any other group.

We must assume that we should adopt common moral guidelines, independent of ambient culture. Prevention of harm is surely advisable, but as with all of human morality, such advisements are unequivocal absolutes (Russel, 1925). However, implementing, via software, more individualized forms of etiquette becomes a major challenge (Hayes & Miller, 2010). Adjusting to these individual and group expectations will be an important imperative for successful human–robot interaction (see Hancock et al., 2011; Hancock, Hancock, & Warm, 2009).

GUIDELINES FOR DESIGNERS

Given the ethical and practical implications involved in robot design and use, it is important for us to offer guidelines by which designers can hold themselves and society morally accountable for the design and behavior of robots. These guidelines address not only the supervision of robot behavior but the design of intelligent morality in robots. Therefore, we offer the following as a "moral design code" through which humankind may strive to improve robots.

Codify human morality. A deeper understanding and codification of human morality should be part of the design process before implementing morality into robots (Wallach & Allen, 2009). As can be seen in the example of capital punishment, humans are unable to agree what constitutes moral behavior, yet such agreement is important for the enforcement of moral robots. Codification of human morality is furthermore complicated by differences in deeply rooted moral standards found across cultures (see Haidt & Joseph, 2004; Hofstede, 2001). It is therefore important that humans decide on a set of morals and set standards for themselves as well as robots. These morals should ideally rise above the divides of culture.

Codify robot morality. Once a framework of human morality has been established, designers should hard-code morality into all robots in a way that cannot be easily circumvented (Gips, 1995). Such morality should be based in human morality and should also contain some of the complexities involved in human morality. As stated previously, an important part of codifying robot morality may involve coding emotion into robots (Arkin, 2011). Doing so will enable emotions to be utilized in robots' moral decision making. Furthermore, if more sophisticated emotions need to occur, a higher level of coding can take place (Wong & Perkowski, 2002). Hard-coding morality into robots this way should also make it more difficult for such robots to be turned against their makers.

Implement awareness in robots. To successfully hard-code morality into robots, designers should also implement an internal system of self-supervision as a means of creating awareness in robots (Khan, 1995). Doing so is important for creating such robots that can apply morally based decision making to novel situations. A key purpose of implementing self-awareness is to enable a robot to deal with new environments effectively (Gorbenko, Popov, & Sheka, 2012).

It has also been argued that self-awareness is integral to the programming of emotions, which has been deemed important to allow for moral decision making in robots (Arkin, 2011). Implementing self-awareness is a challenge to software designers, but some ideas have already been tested (see, e.g., Novianto & Williams, 2009), making this a promising guideline to follow.

Govern the use of robots. Finally, a stable and publicly accessible governing structure should guide the use of robots (O'Meara, 2012). Suggestions for implementing a governing structure are becoming increasingly commonplace, most notably in the realms of ethics and law (see Arkin, 2009c). The implementation of morality in robots cannot be achieved without such government to ensure its correctness and consistency. Many governments are already attempting to govern the design and use of robots (see Lin, Abney, & Bekey, 2012).

It has also been suggested that robots be subjected to international humanitarian law (Arkin, 2009b, 2013). This proposal can be taken to a higher level, with governments establishing laws and pacts specifically guiding the use of robots. The recent open letter proposing the ban of certain autonomous weapons (FLI, 2015) is a laudable first step in this direction. A useful next step would be for scientists to sit down with governing bodies across the world and establish an international pact that can be agreed on across countries.

CONCLUSION

Many respected scientists and luminaries have expressed the opinion that tools and technology are morally neutral (see Caulfield, 2015; Chrisley, 2015; Lin, 2015) – that is, they are able to be used for good or bad contingent on the intent and actions of their users. To a degree, this principle appears to be self-evident. Thus, although a preserves jar may be used for, and indeed "affords," storage, nothing prevents a malevolent user from hitting someone with it, thereby circumventing the designer's envisaged intent, however beneficial that original vision might have been. More obviously, a knife may be fabricated as an eating implement, but that same knife can be used to injure, maim, or kill.

In formal terms, the affordance structure of any created implement is not so constrained as to prevent or preclude unenvisaged harmful action. But must this necessarily be the case? Perhaps for simple physical objects that one might term "tools," this assertion is of necessity and is always true; although even that may be an arguable contention.

However, tools have moved on to much more complex forms, which are now capable of dynamically expressing their designers' *ab initio* intent. Whither are moral equi-potentiality and moral constraints in this far more dynamic and interactive world? At present, robots reflect humans. Now is the time to decide whether they are going to reflect the best of humanity or the worst. Their future development will be a telling judgment on our species.

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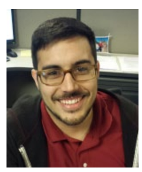
Kimberly Stowers *is a doctoral candidate in applied experimental and human factors psychology at the University of Central Florida. She received an MS in modeling and simulation from the same university. Her research interests include the study of attitudes, behaviors, and cognition in human–machine interaction.*



Kevin Leyva *graduated from the University of Central Florida with a master's degree in modeling and simulation. He received a BS in psychology from the same university. His research interests include automation, ecological research, and design.*

Gabriella M. Hancock *graduated from the University of Florida with a master's degree in applied physiology and kinesiology in 2011. She is now pursuing her doctoral degree in applied experimental and human factors psychology at the University of Central Florida.*

Peter A. Hancock*, PhD, is a Provost Distinguished Research Professor, Pegasus Professor, and Trustee Chair at the University of Central Florida. He recently underwent successful surgery using the da Vinci system and so has reason to be grateful to robots at the present time.*

DOI: 10.1177/1064804616635811