PING-PONG LAUNCHING ROBOT

THE HIDDEN ETHICS OF ROBOTICS

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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(Un)ethical Robots

Hearing the phrase “unethical robot,” one may think of traditional pop-culture icons of rogue machines with goals of human extinction such as T-1000 from *The Terminator* (Cameron, 1984). This archetype of villainous robots stems from a common fear of technology and the unknown, however, is a fictional imitation of a real issue – the ethics of robotics. While most robots are not created with the intent to directly bring harm to humans, a vast majority of the ethical problems behind robots are hidden in the manufacturing process or unintended byproducts of the technology. Some examples of these ethical problems that may not be readily apparent are the large amounts of pollution created by the manufacturing of electronic components, rare-metal mining operations ruining third-world countries, or facial recognition software violating the privacy of the public.

With approximately 80% of total lifetime emissions of an electronic device stemming from the production process, the various hardware elements used in a robot create more pollution during the manufacturing process than several years of use (Evangelidis & Davies, 2021). The metals used in the same manufacturing process produce mass amounts of pollution in their own right – with every ton of rare-earth metals producing 2000 tons of waste (Nayar, 2021). In countries such as Myanmar, Thailand, Vietnam, or Madagascar where mining these rare-earth metals comprises a good portion of the gross-domestic product (GDP), the weak infrastructure supporting the industry collapses when the mines run dry (Cameron & Strasma, 1979). This has created vast uninhabitable regions and the destruction of important ecosystems in these third world countries without the economic, technological, and structural capabilities to reverse the effects (Penke, 2021). This network of problems extends into several other industries and fields but can be linked back to robotics at any point in the network.

A large portion of the ethical concerns with robots is from their use in morally grey areas. The adoption of robots in military, police, or medicinal applications where ethics and morality are already a topic of interest leads to a slew of humanitarian questions (Szocik & Abylkasymova, 2022). In fields where engineers may not be experts, their ability to embed robots with their personal beliefs and values causes unintentional or sometimes deliberate breakage of ethics. Sometimes, robots and their accompanying technology can be misused in ways not imagined by the creators. This is particularly true for artificial intelligence (AI) which is often engrained into robots. AI is frequently used maliciously to impersonate others or hack into systems (Ciancaglini et al., 2020). While these technologies may not have been created for these reasons, bad actors will inevitably find ways to repurpose and abuse these innovations.

This prospectus will analyze unintended negative consequences of robotics, how these consequences are unethical, and possible methods to mitigate the undesirable effects of robotics. To facilitate this, I will use the Ping-Pong Launching Robot (PPLR), compare it with current technology, and explain what could be improved. Actor-Network Theory (ANT) will be used in conjunction to connect the various societal and technical elements involved in this problem.

The PPLR: How It Combats Ethics Issues

Currently, the discussion of ethics in robotics is an industry-encompassing issue. There is no single standard of ethically sound robot or ethically unsound robot. Instead, certain steps should be taken in multiple regards to improve upon the array of ethical problems plaguing robotics.

While manufacturing companies such as Micron, TSMC, or Intel are already working to reduce the footprint of semiconductors during production, the infrastructure for procuring the materials used in the manufacturing process is untouched for the most part (Chandrasekaran, 2022). As manufacturing companies look to reduce emissions during production, mining operations will need to look toward reducing their carbon footprint and reverse pollution in relevant areas. This is less an individual solution and will take years of improvements headed by large groups and governments.

The individually adjustable aspects of creating ethical robots is for engineers to design robots in a way that the technology cannot be misused, reduce harmful biases that could be engrained into the design, and create robots using ethically sourced materials. The PPLR follows all these rules in some manner – making it a good example of what ethical robots should look like. The overall purpose of the PPLR is to be a user-controlled robot and recreational device to play a game with or against. The game it is designed for is to launch ping-pong balls into boxes or cups against opponent in as few launches as possible, although it could be used in other applications such as a ping-pong pitching machine or darts-like game. The complete system can be simplified as a solenoid atop pan and tilt servos to launch the ball combined with a self-correction algorithm on a microcontroller to optimize accuracy and image detection software to keep track of where the ball lands (Takahashi et al., 2021).

A projectile-launching mechanism has obvious ethical concerns due to military implications in up-scalable designs (Rahmani-Nejad, 2021). The PPLR prevents this as it is impractical to launch substantial loads using solenoids – a device primarily used in recreational robotics applying harmless amount of force (Santos et al., 2021). The embedded code on the MSP432 microcontroller is split into two distinct portions: pulse-width modulation motor commands which have no inherent bias and a Kalman filter algorithm exhibiting limited machine learning capabilities (Mao et al., 2019). The Kalman filter is used to accurately determine unknown variables in a system using current data readings in conjunction with previous estimates (Yuhao, 2022). Zhang et al. (2020), used the Kalman filter algorithm in conjunction with object detection for a similar project involving the tracking of golf ball flights. Despite the machine learning capabilities, Kalman algorithms cannot ethically backfire due to their limited overhead and simplicity – showcased in the many recreational use-cases.

The object detection on the PPLR is a point of interest with typical uses of python3 OpenCV being facial recognition – a hot topic in ethics discussions (Fan, 2022). While the PPLR uses computer vision only to detect ping-pong balls in a grid, it is important to be aware that the same technology is used to police and track citizens without formal consent in public locations (Bouras & Michos, 2022). Finally, regarding the sourcing of materials, the carbon footprint of the PPLR is incredibly low as most of the emission-heavy parts such as the microcontroller are reused.

Studying the Human, Technological, and Social Connections of Unethical Robots

The complex web of individuals involved with robotics, socio-political implications of robotics, and examples of robots that can be pointed to as problematic or ethically sound can be naturally deconstructed using Latour's (1992) Actor-Network Theory (ANT) framework. Using ANT, a large-scale system is broken down into its key components, and the mutual effects of each component on the others are then studied. This allows the examples of robots in the network to be analyzed individually as case-studies with predetermined connections to how and whom the technology impacts or the dissection of existing consequences from unethical robot designs pinpointing exact problematic design choices and methods. To determine whether singular design or technology within this network can be considered ethical or unethical, Gladwell's (2015) ethical framework of moral relativism will be incorporated in conjunction with ANT.

In "Where are the Missing Masses? The Sociology of a Few Mundane Artifacts," Latour describes human-made devices such as a simple door as anthropomorphic – where technology exhibits the "moral and ethical dimension[s]" prescribed to them by their design (Latour, 1992, p.157). This emphasizes the significance of examining the many technological, human, and social aspects of a network in order to comprehend the network's underlying socio-technical ecosystem. In particular, the inherent ability of engineers to inject their biases into their creations described by Latour largely agrees with the idea of ethics in robotics being primarily on the shoulders of the engineers, manufacturers, and industry involved in robot design and production.

As an example of how ANT can be used to study the ethical dimension of robotics, the MSP432 microcontroller used in the PPLR will be analyzed using the framework. Starting with the materials used to create the board, approximately 60% of the rare-earth metals typically used in semiconductive and electronic devices worldwide are sourced from China (Garside, 2022). Chen et al. (2022) describes some of the unethical and disastrous results of mining in Jianxi, China on local watersheds and nearby bodies of water. Then, the production process of the microcontroller chip is responsible for over eight times the already-significant footprint of the raw materials used in the chip (STM, 2022, p. 1). Duisterhof et al. (2021) describes the use of microcontrollers on nano drones which have been used by militaries of the world to spy on and even kamikaze onto targets (Dilanian, 2021). The MSP432 microcontroller being the actor of interest in this ANT analysis, the various socio-political concerns of carbon footprints and unethical uses can be related to one another. In a complete network framed around the PPLR, the other actors such as myself and my peers, image detection software, and unintended use cases will have their own set of ethical questions.

Willems et al. (2022) explains an experiment where the humanization of robots will make them seem more ethical in public eye. They found that besides the inherent biases they unintentionally attributed to robots as creators, the biggest impact on the ethicality of a robot was made when social and public values were upheld by the design of the robot. Based on this, it is safe to say that the unethical concerns can be kept to a minimum when the existing network's socio-technical system is respected and integrated into the robot design process.

How Have Regulatory and Policy-making Bodies Impacted the Development and Goals of Robot Design

This research question frames the problem of ethics in robotics in a somewhat backwards manner. It tackles the problem of unethical designs from the viewpoint of an engineer: with regulations and design considerations of robotics having been changed as a result of groups pushing to reduce the unethical consequences of robotics. It provides a more in-depth understanding of both the technical and socio-political sides of robotics and has extensive documentation to support in the analysis of the problem.

To help answer this research question, Latour's ANT framework will be implemented in conjunction with Gladwell's idea of moral relativism. By looking at individual pieces of legislature and their various connections to relevant designs and technology within the network, the question will be taken at face value. The connections between the actors in the network will naturally fill in to be the impact each piece of legislature has had on the relative morality of robotic design.

Policy and agency reports will be crucial for ecological concerns in pollution stemming from the production of computer parts. Legal ruling involving robots created for the purpose of causing harm and robots unintentionally causing harm will likely highlight the visible ethical concerns with robotics. For these reasons, using legal rulings, policy documents, and agency reports will be at the core of how this research question will be analyzed.

PPLR and ANT: Combatting Unethical Robots

As a rapidly growing branch of engineering, robotics has various applications in medicine, manufacturing, locomotion, research, and education (Chowdhury, 2022). Despite its usefulness, the field is laden with concerns about ethics. A vast majority of these concerns reside in the pollution caused by the manufacturing and industrial processes, harmful misuses of the technology, and the unintended consequences of introducing robots in certain environments. In most cases, these concerns transcend beyond simple ethics and negatively harm the environment and people around them. To combat this, the PPLR designed by team Powell Rangers in ECE 4991 capstone serves to be an example of what an ethical robot should look like. In the design, the reusing of parts, prevention of dangerous misuses, and being knowledgeable about inherent biases all serve toward making a more ethical robot. The ANT framework will be combined with this to allow the problem to be framed in a manner such that individual components of the network can be related to certain ethical concerns. Once completed, these two components will be an example of how robots should be designed in order to minimize unethical problems with robotics.

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