Interactive Qualifying Project
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Stories for Robot Ethics Education

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Introduction

Since robots were first introduced into the manufacturing industry in the 1960s, they have become increasingly advanced and useful in a variety of different fields (Siciliano 2016, 1). Robots are currently being used for manufacturing, cleaning, healthcare, transportation, search and rescue, space exploration and more (ibid.). In the future, robots will be as widespread as smartphones are today, and people will interact with many robotic devices on an everyday basis (ibid.). There will be robots in homes, schools, streets, stores, factories and other places where they can assist humans, save lives, or increase productivity and efficiency.

While robots can provide significant benefits to society, there is also a multitude of risks and ethical concerns that need to be considered as these technologies become further integrated into our lives. It is critical for engineers, policymakers, and anyone who interacts with robots to understand and discuss these ethical concerns. Policymakers should be aware of potential issues with robotic technologies and take early actions to prevent or minimize problems. Since policies and regulations cannot always keep up with the fast-paced growth of technology or predict every issue that may arise, engineers must consider ethical implications of their work as they design, develop, and test new technologies. Additionally, consumers should have an understanding of what risks they are taking when they use these technologies. When all parties involved are able to understand and have meaningful conversations about ethics in the field of robotics, risks can be minimized, preventative measures can be taken, and solutions that take into account multiple perspectives can be developed.

Our project aims to provide an interactive tool that can be used by engineers as well as the general public to learn about ethical implications in the field of robotics. Our goal is to initiate discussions, inspire people to investigate these topics further, and bring to light issues that are less commonly addressed. These issues include how robots can challenge humans' sense of identity, ways that robots can perpetuate biases and discrimination, and the challenges of determining the responsible party when a robot causes harm. To realize our goal, we created a website that presents accessible stories, thought-provoking ethical questions, and resources on ethical implications of major robotic domains. After viewing our website, individuals will gain knowledge on primary robotics topics and the related ethical problems behind each of the application domains.

This report will outline our process for researching robot ethics, creating engaging stories to convey major issues in robot ethics, and developing an interactive website that features these stories. Each section of this report will cover a specific task within the project including background research, survey, story writing and website design. For each activity, we will include a methodology of our approach to that task and a discussion of its outcomes. Finally, the conclusion will reflect on the outcomes of our project, the challenges faced, and how the project can be further developed in the future.

Background Research

In order to understand the ethical implications of certain technologies, we must start by considering the fundamental purpose of technology as it relates to our existence as humans. To guide our research, we started by approaching broad yet essential questions such as: What is technology? What role or influence does technology have in our society? Does technology detract from or complement our humanity? Guided by readings from Hannah Arendt's *The Human Condition* (1958) and Val Dusek's *Philosophy of Technology: An Introduction* (2006), we engaged in philosophical discussions on these topics. While there is no perfect answer to any of these questions, the conversations and readings pushed us to develop a questioning mindset and gave us a broader perspective on how views of technology have changed over time.

Narrowing our focus on robotics and aiming to understand how robots will influence society as robotic technologies advance, we examined possible future scenarios in Illah Reza Nourbakhsh's *Robot Futures* (2013). This book provided engaging and accessible stories along with analyses of potential issues brought about from the development of robotic technologies in the future. While reading *Robot Futures*, we created concept maps showing important relationships between concepts and themes we identified in each application domain such as privacy and government in distributed robotic systems. Two examples of concept maps created for chapters 1 and 5 are shown in *Figure 1*, concept maps for all chapters can be found in *Appendix A*. The concept maps helped facilitate our discussions and understand the connections between each technology and underlying ethical issues. Guided by Harvard University's *Principled Artificial Intelligence: Mapping Consensus in Ethical and Rights-based Approaches to Principles for AI,* which outlines eight key themes underlying the principles of AI, we organized ethical issues in robotics by theme (Fjeld 2020). Through these discussions, we

identified common ethical themes such as human rights, accountability, safety, security, identity, and government, which repeatedly appeared in different scenarios or with different technologies.

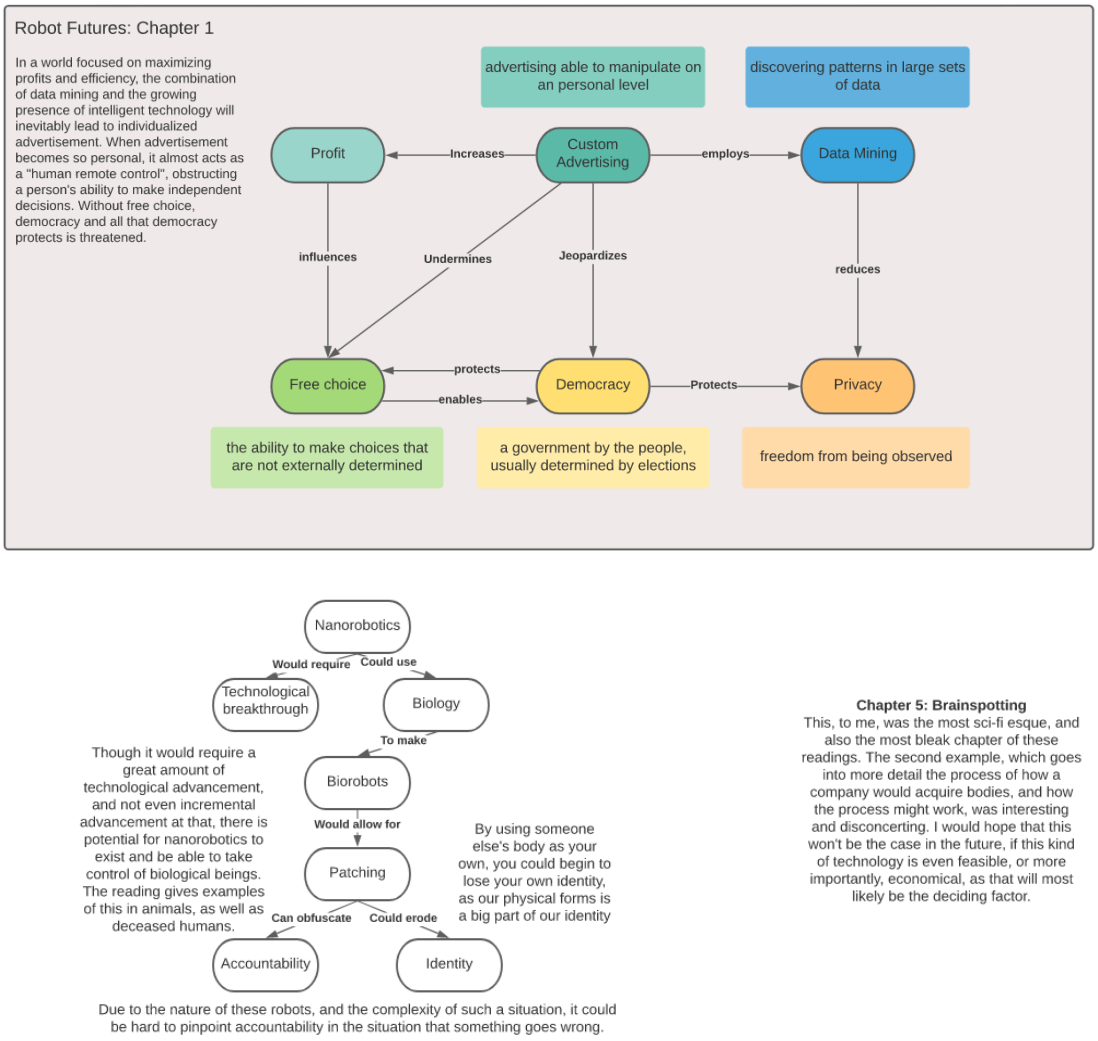

Figure 1 - Concept maps of Robot Futures Chapters 1 and 5

Having considered many of the ethical concerns that will arise as robots become further integrated into our society in the future, we needed to better understand what robotic technologies are present today and how those fields will likely advance. For this information, we turned to Bruno Siciliano and Oussama Khatib's *Springer Handbook of Robotics* (2008), an authoritative text on robotics and different application domains. The book's chapter on robot ethics outlined important ethical concerns in different branches of robotic fields. Many of the

robotic domains had specific concerns associated with each ethical theme we had previously identified.

In order to organize the relationships between themes and domains, we developed a table with robotic domains on one axis and ethical themes on the other axis. Each intersecting cell on the table contained ethical questions concerning the ethical theme within that specific domain. As an example, a subsection of the table is shown in *Figure 2* and the full table is in *Appendix B*.

Domain/ Theme	**Humanoid Robots**	**Industrial Robotics**	**Domestic Robots**
Human rights	Should these robots have the same rights as humans?	Are industrial robots taking people's jobs bad or an opportunity to progress?	How will this affect people's attitude towards robots and how robots will be treated? Additionally, is it right to have a robot raise a child?
Government	Should these robots have protections under the law?	What will governments do to ensure that people displaced by industrial robotics in their jobs will still have a source of income?	Could the robots be hacked and used to spy on individual households?
Accountability	In the event one of these robots causes a serious issue, will they be held accountable themselves, or will that blame fall to someone/something else?	If people are still working alongside robots in the future, and an accident occurs, will the human worker be more at fault?	The robots that care for children will inevitably have an impact on their development, and if this has negative impacts, are the parents at fault or is the robot/company?
Safety and Security	If these robots are used commonly enough around other people, they should be safe and secure enough that there is no risk of them harming someone.	When there is robot/human interaction, how much will the safety guidelines of existing workplaces adapt to this, and will it be enough?	Would these robots be responsible for the safety of children present in the house? Could these robots accidentally start a fire in someone's house?

Transparency/ Explainability	Since humanoid robots will all probably look quite similar but have different directives, these directives should be transparent to people.	Companies should be transparent about what processes they plan to automate	Any shortcomings or potential problem-producing quirks of servant robots should be made very apparent to consumers in order to prevent accidents.
Fairness and Non-discrimination	How will companies that mass produce robots make decisions about the race, gender, ethnicity..etc that these robots appear as? How will these decisions influence the treatment of people that these robots are modeled after?	Will the people displaced by these robots be displaced based on discrimination, such as non-white workers being displaced at higher rates than other workers?	If there are robots that end up teaching people, any inherent bias from the designers could end up influencing others, and perpetuating those biases.

Figure 2 - Subsection of table of robotic domains and ethical themes

When choosing domains to include in the table, we discussed how different subfields of robotics fit together and determined how each is distinctly different in use and ethical concerns. Our full table included 11 different robot domains and 12 ethical themes. We filled in the table based on our discussions of *Robot Futures* and *Springer Handbook of Robotics* as well as conducting additional research on domain-theme intersections where we had gaps in knowledge. While not every domain had relevant questions for every single theme, we were able to develop useful questions for the majority of the intersections. The ethical questions served as useful starting points as we proceeded with more in-depth research of each robotic domain and their associated ethical implications.

In order to effectively start an informed conversation about the ethical concerns of robotics in the near and semi-distant future, we have focused on eight application domains in robotics: Biomechatronics, Companion Robots, Distributed Robotic Systems, Domestic Robots, Humanoid Robots, Industrial Robots, Military Robots, and Surgical Robots. These domains represent major fields of robotics that will inevitably affect our lives going forward. Our research within each application domain brings up major ethical challenges that relate to the themes we identified in our table.

Surgical Robotics

Surgical robots are becoming increasingly advanced and common in the healthcare industry. These robotic systems can be controlled by surgeons' direct actions, semi-automatic which constrain the surgeons movements, or automatic which are programmed before the operation (Sharkey 2013). Surgical robotics is especially useful for minimally invasive procedures where it can reduce patient recovery time and possibly increase accuracy and precision (Siciliano 2016). Surgical robots can also be helpful for neurological procedures that require very fine, delicate movements that are difficult for surgeons to perform (ibid.). While current surgical robotic systems are controlled by surgeons, it is possible that in the future surgical robotics will be fully autonomous.

One major ethical theme to consider in the field of robotic surgery is accountability. When a human performs surgery they can be held legally liable for if the surgery goes wrong, if a robot makes a mistake during surgery there is a question of who should be held accountable (Stahl 2016). A robot does not have the capacity for moral reasoning, so how will it deal with ethically problematic situations (ibid.)? A robot cannot be held liable or face legal penalties, so it is necessary to determine which humans are criminally responsible (O'Sullivan 2019). Is the technician controlling or overseeing the robot at fault? How about the company that designed the robot? What about the doctor who recommended robotic surgery to the patient? The answers to these questions are currently being debated and it is important that robots do not be used as a scapegoat by medical professionals (Mavroforou 2010). Furthermore, if an error occurs in robotic surgery, will the robot be able to explain what went wrong? Accountability is defined as “the capacity of a system to give an explanation for its actions" (O'Sullivan 2019). Algorithms used by surgical robots should be explainable so that doctors can check what the robot has learned to prevent the robot from learning incorrectly and to understand the causes of mistakes the robot has made (O'Sullivan 2020).

Surgical robots are often trained using machine learning algorithms which use large datasets to optimize accuracy and precision of the system. While machine learning can be very effective for achieving highly accurate and robust algorithms, it is often difficult to explain exactly how these algorithms work. The algorithm learns based on the training data given to it

and if the training data contains biases these biases will become present in the robot's performance. For example, a robot might be less capable in situations that were rare in its training dataset which may include minority groups, people with pre-existing conditions, or age groups and genders that the specific type of surgery is less common for (ibid.).

It is critical that patients are able to give informed consent before receiving robotic surgery. The patients may be unaware of the newness of the technologies and lack of evidence about its risks (Geiger 2015, Sharkey 2013, Siciliano 2016). The doctor should be able to explain the benefits and risks of robotic surgery specific to each patient (Geiger 2015). Robotic surgery presents a potential conflict of interest; surgeons may be biased towards robotic surgery due to the "career benefits and status of being an 'innovator'" (Sharkey 2013, 58) or because of the investment of training time and resources that the hospital has spent on the robot (O'Sullivan 2020). In many cases robotic surgery could be more accurate and precise than human surgery; however, higher risk patients may not be the best candidates for robotic surgery and "appropriate case selection for robotic surgery should be made to maximize patient outcomes and minimize chances of complications" (Larson 2014, 291). The patient should also be made aware of the financial cost of robotic surgery. New technologies are not always covered by public health insurance and many patients may not be able to afford robotic treatment (Mavroforou 2010).

There are many risks to robotic surgery but there are also many ways the healthcare industry can minimize these risks through organized systems and protocol. Hospitals should "ensure that surgeons have the requisite level of knowledge and experience, the right tools and resources, and a well-trained support staff familiar with the technology" (Sharkey 2013, 58). To facilitate this, there should be an organized system for credentialing surgeons in robotic surgery and surgeons should be required to regularly renew their credentials to ensure they are up to date on the latest of this fast-changing technology (Geiger 2015, Larson 2014). Furthermore, industry representatives from the companies producing these robots should be present to ensure equipment is functioning properly (Larson 2014). Protocols for training and review should also be set to prevent robots from learning inappropriate actions and to review outcomes in an ongoing manner to evaluate safety of the robot (Geiger 2015, O'Sullivan 2020, Sullins n.d.). Finally, surgeons should always prioritize patient safety by selecting appropriate candidates for

robotic surgery and switching to another surgical modality or aborting the surgery altogether when needed to maintain patient safety (Larson 2014).

Distributed Robotic Systems

Distributed robotic systems are systems of robots linked through a network, such as the web, for data sharing and cooperative learning and working (Siciliano 2016). Distributed robotic systems can be multi-robot systems in which self-organizing robot teams work in coordination to perform specific tasks (ibid.). These systems can also include networked intelligence systems such as smart cities, which have a mixture of networked devices such as weather monitoring systems, smart street lights, and traffic management systems and robotic systems such as robotic police officers. With robots becoming increasingly advanced, smart cities will likely integrate more robotic technologies in the future.

Distributed robotic systems are becoming further integrated into society as the market for Internet of Things technology, such as Amazon's Alexa or Google Home, grows and Web speeds improve (ibid.). This is a popular field of research because there are many benefits to using a system of many robots working together.[1] Multi-robot systems are more adaptable because they are not designed for one specific task (Kagan 2019, 13). They are more reliable because if one robot becomes damaged, the rest of the system remains intact. They are also very useful for large scale applications because a system of multiple robots can spread out across an area to sense and act over a larger space. While an individual robot can only gather information from its immediate surroundings, a distributed robotic system can access information from its own surroundings as well as the surroundings of other robots in the system. An example of this is military microdrones which communicate with each other on intelligence gathering missions (Tarantola 2020). Despite the usefulness and convenience of distributed robotics, there are many ethical concerns associated with these systems including privacy, security, transparency, fairness and non-discrimination, and identity.

[1] Robots are commonly defined as "any automatically operated machine that replaces human effort" (Moravec 2021). By this definition, devices like Alexa and Google Home are not robots because they cannot apply mechanical power to their environments. As the technology for robots advances in the near future, however, these types of networked intelligence systems will serve as the 'brain' of distributed robotic systems.

Networked intelligence systems and distributed robotic systems collect massive amounts of data and it is difficult to give notice and get consent for data collection when citizens are interacting with a large number of data collection devices on a daily basis (Kitchin 2016). Even when consent is obtained, it "often consists of individuals unwittingly signing away rights without realizing the extent or consequences of their actions" (ibid., 9). While the data collected can be used in ways that benefit citizens, such as the smart city technologies intended to improve quality of life of citizens, it can also be a threat to free choice and civil liberties. With this data in the hands of large corporations or a corrupt government, "human rights organizations are legitimately concerned about mass surveillance as a threat to civil liberties. A corrupt government can get to know your every move, habit, medical problem, and other private details" ("Ethical issues of smart city" 2020). It is important to have consent and transparency data collection; however, it is also crucial for the consumer to be educated on the risks of data collection.

Systems containing large amounts of data will be targeted for cyber attacks. While companies put effort into making their technologies secure, there is always a risk of a data breach or cyber attack; "preventive measures alone are not enough for dealing with adversaries" in cyberspace (Rehberger 2020, 1). Large companies including Apple, Amazon, CVS Health, and many others have faced data breaches in recent years (Haqqi 2021). In addition, some companies or governments may take shortcuts with regards to security to save time or money and "some government systems are simply corrupt to the point they cannot guarantee decent protection of their citizens' personal data" ("Ethical issues of smart city" 2020). Especially as society becomes increasingly dependent on these networked technologies, more attention should be paid to how a cyber attack would impact communities (Kitchin 2016).

Robotic police forces have been introduced in recent years as part of smart city technology. On one hand, robotic police forces without the use of algorithmic profiling could present an opportunity to reduce biases that are present in a human police force. However, many robotic police systems rely on machine learning algorithms for profiling ("Ethical issues of smart city" 2020). Since the datasets used for training the robotic police force come from an already biased law enforcement system, these biases will also be present in the robot; "in 2016, a coalition of US civil rights organizations picked predictive policing apart with a joint statement

describing the technology as ‘biased against communities of color’” (ibid.). The use of data for profiling or grouping people can also lead to deindividualization.

> “When group profiles are used as a basis for decision-making and formulating policies, or if profiles somehow become public knowledge, the individuality of people is threatened. People will be judged and treated as group members rather than individuals” (Van Wel 2004).

In any case where data is used to train an algorithm, it is important to examine what features the training is using to group people, analyze what biases may be present in the dataset and form a strategy to limit these inequalities.

Companion Robots

In developed countries, especially Japan and the United States, the aging society is gradually becoming a challenge, and other countries in development tend to face the same issue. The caregivers for the elderly will be in a significant shortage shortly (Jason 2019). Companion robots can be an effective solution to this problem. Companion robots already exist, and some of them have been used in care settings for more than a decade in multiple countries (Hung 2019). It turns out companion robots are more difficult for the public to accept them than people thought (Johansson 2020).

Use the most discussed care robots for elders as an example. Their primary target, the elders, has a hard time accepting the companion robots. They have more negative feelings taken care of by robots (Johansson 2020). According to the research, the elders feel they are losing their rights. Privacy is hard to be guaranteed if we want robots to help elders to keep them safe (Sharkey 2012). Should the companion robots follow, monitor the care recipients at any time, including in the shower or bathroom? Reporting care recipients' activities and location to their families and doctors might also invade privacy. How could we find a balance between the care recipients' rights and safety? Another reported problem is that the care recipients feel that they are losing control and independence of their lives (Sharkey 2012). Getting arranged by companion robots means the care recipients might lose the autonomy of their own lives, which in turn makes care recipients feel uncomfortable (Sharkey 2012). To ameliorate this problem,

increasing care recipients' autonomy can be an effective way. Indeed, companion robots are proved helpful in the prevention of depression and dementia (Hung 2019). The precondition is that the care recipients are willing to interact with companion robots. However, individuals, especially males, might feel embarrassed interacting with companion robots in front of other people, significantly influencing their performance (Hung 2019). At the same time, the presence of human caregivers (e.g., nurses) might also make care recipients feel embarrassed in situations like changing diapers. Companion robots do not make care recipients feel the same way, which can be advantageous compared with human caregivers (Sharkey 2012). When building emotional connections with companion robots, deception and infantilization can also be a problem. To interact and communicate with companion robots, the care recipients must periodically deceive themselves into believing that companion robots can build emotional connections with humans, even if they know robots do not have feelings. Some people view this as infantilization for asking them to make friends with robots (Sharkey 2012). Based on that thought, some people believe companion robots cannot give true care. All those emotional connections with companion robots are just built on deceptions, which might increase the care recipients' loneliness and isolation (Wachsmuth 2018). According to the research, the visits from families decrease after the care recipients start to live with companion robots (Johansson 2020).

In sum, there are many promising potentials in companion robots, but also related problems we need to think about. How to maximize the benefits of companion robots and minimize the ethical issues is a challenge we need to address. Increasing the autonomy of care recipients, letting the care recipients--not the families nor the doctors--control the companion robots, and listening to what care recipients need can be a good start.

Humanoid Robots

The humanoid robots are robots whose body shape and face resemble the human appearance. Due to that feature, the humanoid robot is one of the most controversial topics in robot ethics, and it has been the heated discussed topic in many fiction novels and movies. People always think about how a society coexisting with humanoid robots will be like and how to solve the potential ethical issues. Before discussing the ethical issues of coexisting with humanoid robots, we should think about why we even need humanoid robots first. Some people

believe that humanoid robots are just the wrong answers to the right problems, and robots that look like humans are immoral and creepy (Ryan 2019). In the future, humanoid robots have an immense chance to be integrated into nearly every aspect of our lives, including public education to privatized uses such as interacting with children. When we get along with humanoid robots and even build emotional connections with them, how can we differentiate between robots and humans since they look so similar? It is a hard question even for an adult, let alone children whose cognitive capabilities and understanding of intimate relationships are still developing. How can we correctly lead children to build healthy relations with humanoid robots? The appearance of a humanoid robot can be confusing for a child. According to the research, the younger a child is, the harder it is to tell the difference between a humanoid robot and a human (Kahn 2012).

Another problem when we talk about coexisting with humanoid robots is human rights. If we endow humanoid robots with human rights, we have no active rights to rule over the robots and treat them like slaves (Stephy 2019). If we educate people that humanoid robots should not enjoy the same rights as humans, are they accountable for their mistakes because of the wrong program? Humanoid robots' sensation or perspicacity can be a crucial point to help us decide when it comes to rights and accountability. As long as humanoid robots are self-aware of their existence and obtain equal status as humans, we can not use robots and ask them to work for us anymore because it invades the rights robots enjoy (Stephy 2019). However, it is challenging to guarantee that robots without a complete understanding of human emotions will not harm other humans since they lack empathy. As a result, people should not expect humanoid robots to protect humans unconditionally if they have complete autonomy. They can not understand humans' emotions without sensations as well. As a result, rules will definitely be needed to guarantee humans' safety. Besides physically hurting people, which can be easily prevented by programming or set the rule, humanoid robots without sensation can cause other problems. According to the research, robots' involvement in business can ruin the trust between the people involved in traffic as automation tends to ignore the vital aspect of human interaction, such as morale, to maximize profit (Nicholas 2019). As a result, if we live in a society getting along with humanoid robots, one of the most important things is building the corresponding rule or law for humanoid robots to obey. Society should clearly understand the differences between humanoid robots and humans and have different expectations towards them.

Last but not least, we should discuss who is responsible for the outcome (either bad or good) caused by the robot's action, either by order or autonomous action. According to the research, most people believe that humans, like programmers or manipulators, should be more accountable than humanoid robots (Peter 2012). The government and the expertise should make up a sound law, from restriction to accountability, to prevent the potential risk. However, some people also think if we treat humanoid robots and humans differently, we are legislating discrimination (Stephy 2019). It is both the professional and government's responsibility to find a balance in between. Generally speaking, we still have a long way to build a society coexisting with humanoid robots. Hopefully, by then, we can find a better approach.

Biomechatronics

This more recent robotic domain is characterized by the integration of mechanical and electrical technology with biological organisms in an effort to improve and/or expand biological functions. Development of this field seems to follow at least one of two trends, to use biomechatronics to eliminate disability (E&T editorial staff, 2020) and to expand the senses of the human body (Harbisson., 2012). These avenues of technological progress open ethical lines of questioning for the biomechatronics domain. The ethical issues that emerge in this domain are human rights, identity, human control of technology, fairness and discrimination, and last but not least government.

Using biomechatronics to eliminate disability primarily started with the creation of more advanced prosthetics that bridged the gap between traditional prosthetics and what we know today as biomechatronics. A great example of this and a leading researcher in biomechatronics is Massachusetts Institute of Technology Professor Hugh Herr. Herr lost both of his legs while climbing Mount Washington and soon after committed to developing high grade biomechatronics for other amputees and other devices to help eliminate disability (Kirby, 2018). Opening up this path of development links the domain with the government as well as fairness and nondiscrimination ethical themes. With the goal of eliminating all disabilities possible with biomechatronics the technology must first overcome some challenges. The integration of new medical devices into the current medical field is no easy task. For biomechatronic procedures to become available to everyone, government and medical organizations must develop regulations

and procedures asking questions, like when will the devices be considered to be needed? Or is it immoral to deny biomechatronics to someone even if they don't need them to survive? Currently biomechatronics are obtained primarily through people who seek out and pay large amounts for the technology, but Herr has already begun presenting research to Centers for Medicare & Medicaid Services to get the devices to all patients who need them (Johnson, 2014).

Although biomechatronics have great applications in the medical field, they are not reserved for only eliminating disability. People have begun to get biomechatronic implants that expand the capabilities of their body. A simple example are radio frequency identification chips (RFID) people get in their hand in order to eliminate the need for credit cards, keys, or even identification cards. A more drastic example is the story of the cyborg artist Niel Harbisson. Being born color blind Niel Harbisson was not going to let that keep him from perceiving color, he got a biomechatronic brain implant that associated colors with tones he hears when the camera attached to his implant is pointing at something (Harbisson, 2012). This implant, although at first created to eliminate color blindness, could then easily be adapted so that the cyborg artist could perceive color outside of the human visible spectrum, allowing him to extend a sense past that of human capabilities (Harbisson, 2012). This path of innovation opens the domain up to the identity and human rights ethical themes. This type of use of biomechatronics allows everyday people to improve and even add functions to their body for convenience, practicality, and self expression. Trying to develop regulations for what type of biomechatronics people should have access to becomes more difficult in this area. Who is to say what body augmentations to their own bodies out of self expression? That being said there must still be some type of regulation to prevent people from getting biomechatronics that could purposefully or accidentally hurt themselves and others.

Despite their differences, both avenues of development connect to the ethical theme of human control of technology. Either way this level of integration of technology with the human body has not yet occurred. How will making robotics an extension of ourselves affect how we interact and view all technology? Biomechatronics will not only change how we use technology, but make it become a part of us. This will change how we interact and view all technology.

Domestic Robots

Domestic robots, also known as household robots, are automated devices used to improve one's homelife, usually by doing chores like cleaning. Modern domestic robots, like the Roomba, don't spark much inquiry into ethical concerns but as the field evolves we must be ready to face issues within the ethical themes of accountability and safety and security.

Domestic robots, like living creatures, can either be specialists or generalists. Current domestic robots are mostly specialists (Homigold, 2018). Take the Roomba, it was designed to do a single thing, vacuum the floor, and even with that single purpose it is still limited to a single floor and by its incapability to learn and improve upon its function. Generalist domestic robots are widely thought of as the future domestic robots. They are able to complete numerous tasks autonomously and learn how to better complete them for the individual household. These robots are usually thought to be humanoid so as to make them more familiar to people as well as ease of movement throughout the house. These features make generalist domestic robots sound like robot butlers from the future, but robots like this already exist (Homigold, 2018). Honda's Asimo robot is a humanoid generalist robot first introduced in 2000. The robot has auditory, visual, and tactile senses of a person and is able to use information gathered from its surroundings to determine the best possible course of action (Honda, 2011). This allows Asimo to think and interact not only with its environment, but also people. The robot is able to keep track of a conversation, predict movement patterns to avoid interfering with others, and even has alternative forms of communication such as basic sign language (Honda, 2011).

As generalist domestic robots become more common we must start conversations within the ethical themes of accountability as well as safety and security. Accountability is a major factor for generalized domestic robots in more than one way. One way it comes into play is who will be considered responsible if the robot makes a mistake or malfunctions in a way that causes damage to people or their property? Current liability law is quite flexible and might be able to settle the first few disputes, but as technology evolves and the robots become more adept at learning and to modification from owners it could become harder to pinpoint who blame for an incident lays upon (Ebert, 2020). Safety and security play a larger role on the corporation side of producing the robots. If there is a robot constantly monitoring your home and learning from the

people and environment within, how will companies make sure that customer data is safe as well as make sure no one could use a domestic robot to harm anyone else? This could prove to be difficult as data miners and do it yourself (DIY) modifications become more commonplace with more people taking advantage of vulnerabilities in technology.

Industrial Robotics

Industrial robotics, given that they are extensively used and have a palpable effect on the population, are brought up often, particularly in regards to the job displacement that automating the work force brings. While, as a whole, this issue is indeed important, there are other aspects of the problem that are lesser known, and bringing awareness to these complexities can aid in understanding the effects of industrial robotics as a whole, as well as bring to light how these issues overlap with others.

For example, while displacement can affect a wide variety of people, especially as automation gets more and more advanced, and more capable of completing a wider gamut of tasks, marginalized groups have the potential to be disproportionately displaced compared to others (Brussevich, 2019). Certain groups of people may be more likely to get jobs that can be easily automated, meaning that that group is affected by the automation of their field more than others. While displacement is an issue that can affect many, it compounds with other issues and creates intersections where people are affected more than others.

Despite this, studies show that people find layoffs due to automation to be more fair than those caused by outsourcing, or in general that it is more fair when a worker is replaced by a more efficient worker, automation included (Wakslak, 2019). Additionally, while automation does indeed cause a “direct displacement effect” which lowers labor demand, there are additional forces which work to counteract this, such as reducing the cost of production as well as further improving already automated tasks (Acemoglu, 2018).

Those replaced by an automated workforce may have the potential to seek employment in fields created or expanded upon with an increase in automation. In the case of Artificial Intelligence, many new types of jobs will potentially become quite commonplace, such as Trainers, who aid artificial intelligence in learning things like sarcasm for example, or to help reduce bias that might be inherent. Other types of jobs include Explainers and Sustainers, who

work alongside AIs, coordinating the use of them as well as their integration into current work (Wilson, 2017). However it is not yet clear if these jobs will be enough to counteract the displacement caused by automation.

Workers who maintain their jobs even in the face of automation may experience changes in other ways. In the process of delineating what jobs should be reserved for human work and what will be automated, workers might get the impression that their work is just going to be reduced down to something repeatable and automated (Nourbakhsh 2015). Additionally, for workers who work around industrial robots, it can have a negative affect on their human to human relations. While not everyone will be directly affected by their workplaces being automated, there will still be changes like this that can have a negative impact.

Military Robotics

Due to the nature of military research, and the kind of controversy that surrounds war, it can be difficult to identify what is actually current and relevant, especially given that some things may be classified or not well covered. It would be hard to discuss the potential ethical concerns and issues surrounding a topic when one does not understand the topic well, and so it is important to give a good idea of what is currently capable in military robotics, as well as where it might lead.

Since military robotics have the potential to be 'game changing' in war, or at least having the potential for significant negative effects, establishments such as the Geneva Convention setting rules in place before they can become an issue (Bowcott, 2015).

Military robotics also face an issue that many other types of automation can have, which is understanding the 'responsibility' of the robot. This is typically relevant when a robot is involved in some sort of accident involving injury or loss of life. In the case of military robotics, that can be applicable in the situation where there is an unintended casualty, potentially as a result of the robot misidentifying someone (if it is capable of seeking specific targets). Which parties take responsibility for such an incident is a tricky matter and can be complex to figure out, which has the potential for issues. (Noorman, 2014).

The morality of military robotics is also very complex given that war in general is a very morally grey area (Hellström, 2013). One's opinion on automation in the military could vary greatly depending on what they believe about war in general; One person may have no qualms about a machine with the agency to take a life, while another may already have issues with a person taking another person's life. In any case, facts about how military robotics might perform, their advantages and disadvantages, as well as other useful information would allow someone to better form their own opinion on the technology as opposed to being less informed (Brown, 2007).

Survey

To better understand how students with a technical background perceive robot ethics, we conducted a Robot Ethics Lab questionnaire to ask students at Worcester Polytechnic Institute (WPI) to consider moral questions brought by robot development. We chose a questionnaire as our survey tool because it is more cost-efficient compared to other survey tools like interviews. Moreover, online questionnaires can automatically compile collected data and display simple visualisation like pie charts (Jones 2013).

Our survey was approved by the Institutional Review Board (IRB), a committee that guarantees the participants' rights, welfare, and privacy as it contains human subjects. The letter of approval is shown in *Appendix E*. The survey was also anonymous and participants were required to be 18 or older to respond to this survey. For practical reasons, we chose to limit our survey participant pool to WPI students so that we could easily distribute the survey and monitor our survey subjects' demography. Most WPI students are majoring in a scientific, engineering, or mathematical field, which ensures some technical background. Because most WPI students have some knowledge of ethical issues in science and engineering, we expected that they would answer our questionnaire differently than someone with a non-technical background. Collecting responses from engineering students and the general public simultaneously would have made it difficult for us to interpret our results. Distributing the survey within the WPI community was very feasible, we sent out our survey through group chat channels or email lists in different Greek organizations, school clubs, majors, and other personal connections in WPI. In the future, however, this survey could be distributed to the general public to gain a better understanding of

how people with non-technical backgrounds perceive robot ethics. We have already included some explanation of robotics terminology in our survey, so that it should be understandable by anyone regardless of technical expertise.

The survey had sixteen questions in total, as shown in *Appendix D*. The first three questions are about the participants' educational backgrounds and whether they have ever interacted with robots. Those questions allow us to acknowledge the respondents' general background and demography so that we can better analyze the survey results. The fourth question is about the comparison between privacy and the convenience brought by robots. Privacy is one of the primary issues with the development of technology. We would like to know the participant's opinions and choices between human rights and the benefits of robots. We describe this question with a scenario, which allows the respondents to put themselves in a morally-charged situation and provide more considered answers. The fifth question asks people's opinions regarding humanoid robots and robots without human appearance, and the sixth question is related to biomechatronics. Both humanoid robots and biomechatronics are subfields in our research. We believe it is inevitable that humanoid robots and biomechatronics will undergo similar controversies as they share similar external aspects with humans. Our goal here is to determine how people would react once they interact with these robots. Question 6 introduces the background of body augmentations, which enables people who are not familiar with biomechatronics to gain more understanding of the situation. From Question 7 to Question 9, we ask for the participants' opinions on controversial moral concerns such as taking human jobs, building emotional connections with robots, and the general risk with robots. Those questions are common concerns in modern science fiction movies or novels. For instance, most science fiction stories portray the robots' negative side. However, we wonder whether the participants believe the same way as science fiction works present and how severe and influential people believe those concerns can be, which can help us better understand the participant’s view on those heated ethical topics. Questions 10 through 12 ask participants the extent to which they agree with statements that express concerns regarding potential risks in robotics. Question 13 requires participants to rank the main concerns in robotics ethics. The last three questions are open-ended questions, and our goal was to give participants an opportunity to share their ideas--especially the ones that are addressed in previous questions..

In the Robot Ethics Lab survey, we received twenty results. The distribution of answers to the multiple choice questions in the survey can be found in *Appendix F*. Ninety-five percent of the participants answered that they received some college or higher education. Eighty percent of participants had interacted with robots in real life; the rest of 20 percent had heard about robots in real life or online. This result was expected since WPI provides many robotics and robotics-related courses and there are many robots on the WPI campus. The types of robots students had interacted with were mainly domestic robots, robots at school for educational purposes, or combat robots in competitions.

The survey participants were largelyconservative towards the changes brought by robots. When there are conflicts between the benefit brought by robots and people's privacy, most people (65 percent) responded that they would not buy a robot that might leak their private information even if the robot can improve their lives. When it came to humanoid robots, only 25 percent of participants agreed that robots with human traits will benefit society more than robots without human traits. More participants (40 percent) were neutral towards the benefits of humanoid robots. The participants perceived biomechatronics to be more acceptable than humanoid robots. Eighty-five percent of participants believe that people should be able to augment their bodies as they see fit, and only 5 percent of people disagreed with it.

Regarding the moral concerns that robots might bring, the participants were more optimistic than expected. Participants think of robots as more like auxiliary methods instead of solutions in the future. Only 20 percent believe that robots can fully replace doctors and teachers, and 5 percent believe robots can fully replace doctors but not teachers. Most participants (70 percent) believed that robots will assist but not replace doctors or teachers. None of our participants thought the potential risks of robotics outweigh the potential benefits. Seventy percent of participants thought robotics' potential benefits outweigh the potential risks, and 30 percent were neutral. Concerning emotional connections with robots, 45 percent of participants thought humans will have emotional connections with robots. Fifty percent of people think emotional connections with robots depend on the appearance and the utility of robots. Only 5 percent of participants think that humans will not have emotional connections with robots. People who were worried that robots would invade privacy and people who were not are about the same amount. In science fiction movies, there are many plots in which machines acquire a

super intelligence. It turned out that people worrying about robots becoming too smart is about the same amount as people who do not. However, participants had more concerns about the hack of robotics systems Only 25 percent of people were not worried about this.

Among all the concerns related to privacy, cybersecurity, robots surpassing human intelligence, military robots, and robots taking jobs, cybersecurity and military robots were voted as most concerning. The majority of participants rated privacy in the middle as second, third, and fourth most concerning on the scale of 1 to 5. Regarding robots surpassing human intelligence, the rank pattern present was the most extreme; many people voted it as the most concerning, while many other people voted it as the least concerning. Participants viewed robots taking jobs as the least concerning issue overall.

In respect of non-fictional robots' moral concerns, outdoor drones, military robots, autonomous vehicles, and artificial intelligence were the most common concerns to our participants. Many direct reasons they were worried about are that they believe those technologies have risks on humans' security. In respect to fictional robots' moral concerns, artificial intelligence and robots authorized to kill humans are the most mentioned worries. Some people specifically expressed their concerns about the cyber hacking attacks as well.

After viewing and analyzing the survey result, we gained an understanding of how some engineering students at WPI perceive robot ethics. Moreover, we were able to see their major concerns about robot ethics and the reasons behind them. Granted, there are some limitations in our survey results. It is difficult to generalize from our survey. There are similarities between WPI and other tech schools, but they are different in terms of their student bodies. Our participants might also include students whose major is robotics engineering or other robot-related fields. Studying in related areas might make them have more optimistic or conservative opinions towards robot ethics. Additionally, we only received 20 responses to the survey which is a small sample that may not be representative of the WPI community. In general, we found that even within a narrow demographic of only WPI students, there are many differing opinions on how robots will impact our futures and what ethical issues this will bring. For every ethical issue presented in the questionnaire, there were at least some participants who believed it was a valid concern. However, no participants believed that the risks outweigh the benefits of robotic technologies. Ultimately, our survey results did not affect the content we decided to

include in our website, but we hope that WPI students will use our website to learn more about these topics. In future work, a survey that presents questions before and after viewing our website may give us more insight into how effective our website is as an educational tool.

Stories

Multiple studies have investigated the power of stories as an effective teaching tool for ethics education. In his book, *The Ethical Power of Narratives*, Marshall Gregory describes fictional stories as a "moral technology" that shapes and influences our ethos (Gregory 2009, 56). He argues that stories stimulate ethical responses because people evaluate narrative characters by using "ethical categories" to understand their decisions (ibid., 57-58). Through the characters in a story, readers can "vicariously negotiate among different lines of action and thought," considering a wide range of possible consequences in a given situation (ibid., 62). Additionally, Gregory argues that stories are "much more compelling than any other form of learning" (ibid., 62). Beyond the theory of why stories bring about ethical contemplation, studies on engineering ethics education evaluate the usefulness of stories in presenting case studies or scenarios as a teaching tool. Stephanie J. Bird and Joan E. Sieber's *Teaching Ethics in Science and Engineering: Effective Online Education* states that, "case studies may be used in science and engineering ethics courses to enable students to engage in effective ethical analysis and problem solving" (Bird 2005, 326). There are multiple different ways that stories are used in engineering ethics education. Caroline Whitbeck identifies three main uses as follows: (1) open-ended scenarios, (2) complete stories that are cautionary tales, (3) stories of exemplary responses (Smith 2005, 455). Additionally, Richard Epstien presents "The Case of the Killer Robot" scenario, which he designed to simultaneously cover issues in computer ethics and introduce technical material related to software engineering (Epstein 2005). Epstein's approach describes how ethical scenarios can be smoothly integrated into any engineering course while still covering course material (ibid.).

After reading *Robot Futures* (2013), a book that centers discussions of robot ethics around stories about future scenarios, our team experienced first-hand the effectiveness of stories as a tool for initiating conversations about robot ethics. The stories were engaging and gave us specific scenarios to think about when considering the ethical analysis at the end of each chapter.

Moreover, these future scenarios gave our team a context to discuss the ethical topics within, which resulted in compelling conversations about how robots will affect our future. Even when the scenarios did not align with our own expectations of what the future of robotics will look like, we were able to better understand the ethical concerns through the context of the stories and discuss how those topics may apply to other situations in the present day or our own predictions of robot futures. The purpose of the book was not to perfectly predict the future, but to bring up real ethical issues in a striking and thought-provoking way.

When deciding how to best present robotic domains and ethical themes, our priority was to present the information in a way that would be understandable and interesting to any audience, including those without a background in robotics. It was evident that well-written scenarios could provide an engaging and understandable context for presenting ethical issues; however, determining the structure and content of these stories required significant deliberation. We created separate web pages for each application domain and introduced each domain with a story as the first section on each page. The stories were each followed by an informational introduction to the domain, a series of discussion questions relating to ethical concepts in the story, a list of the main ethical themes relevant to the domain, and resources for learning more. The full stories and webpage content for each domain can be found in *Appendix G*.

Our team first considered our audience and the medium through which the stories would be shared. While long and detailed scenarios have proven to be useful in ethics education, as shown by Epstien's "The Case of the Killer Robot", we determined that short stories spanning 3-4 paragraphs each would be an optimal length for this project. Since our stories were intended to engage with the general public through a website, it was necessary to quickly grab the reader's attention. A reader may not be interested in robot ethics before reading our stories, and therefore may not want to invest the time to read a detailed scenario. Moreover, a short length worked well on a website, because "if web users don't find what they are interested in on a page in 60 seconds or less, they move on" ("Short web" 2003, 1). Three paragraphs is long enough to introduce characters, setting, and a morally-charged situation, but short enough that a person visiting our website could read most of the story before deciding to stay or leave our website.

The second decision our team made when considering our target audience was the location where the stories would take place. All of our stories, with the exception of the

companion robots story which takes place in Japan, were set in the United States. We were not comfortable attempting to represent cultures in our stories that we did not have first hand familiarity with, and since the majority of our audience would likely be people who are living or have lived in the U.S., this setting would allow our audience to better identify with the stories. Additionally, when considering our audience, we wanted to take into account diversity of gender and ethnicity. Our goal was to avoid perpetuating stereotypes by subverting gender norms and introducing characters with varying backgrounds. One example of this is in our industrial robotics story, in *Appendix G*, which shows the perspective of a female character in a male dominated industry of cigar rolling. Despite our goal of representing different ethnicities, the names chosen for characters in our stories lacked diversity. To improve representation of different backgrounds, in the future we would like to more carefully consider choice of character names.

Beyond aiming to serve our target audience, our stories needed to creatively present ethical issues in a way that encourages the reader to further explore these topics beyond the story. Although the goal was to bring up as many relevant ethical issues as possible in each domain's story, it was important that the stories flowed logically and did not become laundry lists of ethical concerns. We prioritized good story structure over maximizing the number of ethical issues the story introduces. Instead of blatantly stating ethical issues, the stories needed to present these concerns as part of the narrative. Each story started with an exposition, introducing the characters and setting, followed by rising action as the character faces a challenge. For example, the exposition of the distributed robotics systems story introduces the smart city technology by showing how Tim uses the technology in his morning routine:

> On a winter morning, Tim wakes up to the smell of toast cooking in his *LifeBot* smart toaster. His *LifeBot* virtual AI assistant, Charlie, greets him: "Good Morning Tim! Today it is 35 degrees and cloudy. You have a meeting at 9am and there are currently seven parking spaces available outside your office building." Tim drags himself out of bed and gets ready for work.
>
> *LifeBot* is a massive tech company which rapidly gained popularity over the last 3 years for its vast line of connected IoT devices that can perform a multitude of everyday tasks. *LifeBot* has three major product lines for businesses, households, and smart cities. Tim lives in a *LifeBot* operated smart city and smart home. He loves how well his home devices integrate with the smart city.

Instead of simply stating that Tim uses IoT devices, the story shows how he uses them in his everyday life, allowing the reader to imagine themselves in the scenario. The same story then uses dialogue and plot to bring up the issue of a data breach:

> When Tim gets to the office, no one is at their desks. He goes to the break room and finds everyone watching the news and frantically checking their phones. "What's going on?" he asks his co-worker. She replies, "*LifeBot* had a data breach this morning. I heard it only affected the business management devices but this could mean that our personal data was breached as well. Either way, we can't do much work today until it all gets sorted out." Realizing how much personal data *LifeBot* technology has collected on him, Tim's stomach drops.

Here, the problem of *LifeBot* being hacked is shown through the office setting. The story indicates that something has gone wrong when everyone at the office has stopped working to watch the news. Dialogue is then used to inform Tim and the reader of the data breach that compromised *LifeBot* devices. In both the exposition and rising action of this story, the use of technology and its related ethical issues are shown through the plot of the story.

Our stories also aim to guide the reader towards thinking about the morality of the situations without forcing them to take a specific viewpoint. For this reason, we chose to leave the stories as open-ended scenarios. Not only did this help keep the stories short in length, but it also allowed the reader to consider how they would act in the given situation and form their own judgments (Smith 2005, 455). Many of the stories end with the character facing a difficult decision. For example, in the military robotics story, Darius faces a moral dilemma in his work:

> Previously Darius had only worked on automated systems that either prevented loss of life, such as bomb defusal robots, or were simply used as tools by soldiers, such as recon robots. His increasing discomfort in straying any further from these applications leaves him with a difficult decision to make: He either continues to work, and aids in creating something he does not want to exist, or he quits his job and is forced to find work elsewhere, which would put him in a dangerous position in the current economy. Additionally, Darius could go one step further and actively protest against the creation of such automated applications, which would most likely result in him being fired, but would also make it even more difficult for him to get a new job, as he has seen how difficult it is for whistleblowers to do just that.

The reader is presented with the different considerations Darius must make in his decision, but what he ultimately decides is left open-ended. The reader can think through Darius's concerns

and the issues brought up in the ethical questions to decide what choice they believe Darius should make. A few of the discussion questions that accompany this story are shown below:

- If the actions of the robot result in a wrongful death, who is responsible for this?
- Should an autonomous system have the ability to take a human life without any human intervention?
- Should governments ensure that these systems do not become accessible to independent individuals and groups?

The open-ended structure fit well with the discussion questions presented after each story. These questions push the reader to think about how they would react to the scenario and what ethical concerns would be important to consider. We listed about 7-10 questions for each story with the hope that these questions would inspire deeper thought and discussions while allowing the reader to form their own opinions.

One difficulty of writing the scenarios was minimizing overlap between different application domains. For example, the concern of hacking is relevant to many application domains in robotics. However, if all of our stories centered around cyber security issues, a viewer would not get a full view of all the topics in robot ethics. Therefore, we did our best to coordinate between the stories to ensure they each emphasized different issues, and focused on the ethical concerns that were most consequential and unique to that domain. For example, the distributed robotics systems story centered around a hacking incident because in this application domain a hack would have a very widespread impact and concern the data privacy of citizens. We also aimed to bring up ethical issues that are less commonly thought about for that domain. With industrial robotics, discussing solely the topic of job displacement without any other factors would not give a particularly in depth look at the possible issues in the domain, given that job displacement is already an extensively discussed topic. To add new perspectives to the industrial robots story, we incorporated themes of discrimination and gender inequality.

Another major challenge in developing the stories was finding balance between realism and impact. Based on our inspiration from *Robot Futures*, we chose to have the stories take place in the future. This gave us the freedom to present more advanced versions of technologies and

the accompanying ethical implications that we expect to see in the future. The ethical concerns of the future are likely more shocking to an audience, since they can be more extreme than the present day dilemmas. We state the year that each story takes place in to indicate how far into the future we believe these scenarios could happen. For example, in the surgical robotics story, it is the year 2075 and Sarah faces the decision of having surgery conducted by a fully autonomous surgical robot:

> Sarah is very nervous about the procedure because she has a rare pre-existing condition that puts her at higher risk for complications and she is unsure if she is willing to trust a robot to do the procedure. She brings up her concerns with the doctor and he assures her that the robot has successfully completed the operation many times. He also tells her that if she wants the procedure to be done by a human surgeon she will have to wait at least 2 months. The hospital has been hiring less human surgeons now that robots can do many of the common surgical procedures. Consequently, their schedules fill up far in advance and prioritize operations that cannot be done by surgical robots.

While fully autonomous surgical robots do not exist today, the technology will likely exist in the future as robots become increasingly skilled at operating without human intervention. Fully autonomous surgical robots raise more ethical concerns than the current semi-autonomous surgical robots, because they will likely affect the demand for surgeons and impact the affordability of different types of surgery. It also becomes more challenging to determine who would be responsible for complications in robotic surgery, if a surgeon is not present. These issues are important to think about before fully autonomous surgical robots start being used in hospitals.

Although having our stories take place in the future is helpful for presenting ethical challenges, we acknowledge that this approach has some limitations. It is possible that drawing attention to concerns of the future may make the present day issues appear less significant. Our intention, however, is that after reading the scenario the reader will be motivated to further investigate how these issues are relevant in the present and what actions can be taken to avoid these more extreme future scenarios. Additionally, the introduction to each domain, placed immediately after the story, gives the reader information on the current state of technology in that domain. The resources and quotes provided with each ethical question also present current

research on ethics in the domain. In this way, we use the story to grab the reader's attention while showing both the current and potential future issues within each domain.

While very extreme stories about dystopian futures could be shocking and attention grabbing, they could easily be disregarded when the reader does not believe the situations or similar situations could happen in real life. Therefore, we tried to make the stories realistic based on our knowledge of the field and what advancements we believe are probable. Each story is accompanied by a year, which is our estimate of the time period when we believe the scenario could realistically take place. Of course we cannot predict the future, but even if these scenarios do not become reality, they still raise important ethical questions. By making the stories realistic for their setting in time, we hope that readers will be able to identify with the scenario and see the significance of the issues they raise.

Website

In order to reach our goal of sharing information about robot ethics with the general public, we chose to build a website as part of our final deliverables, see Appendix J. Web-based tools in ethics training of engineering students can make the educational material available to more people in a more convenient and less expensive way. Internet-based technology can help educators reach engineers and engineering students who otherwise could not or would not be reached (Smith 2005). Additionally, the form of the website can be more interactive since it allows the viewers to have discussions among themselves. We included many links and resources in our project.

Our goal in building this website is to educate and inform readers of real-world issues in robotics that may become prominent in the coming years, so that they can better understand and talk about ethical dilemmas our society could face in the near and semi-distant future. This site is intended as a starting point for anyone who is interested in robot ethics. Additional sources are also provided for those who seek to do more reading or gain a deeper understanding of a specific area in robotics. By providing a framework for robot ethics and a conversation platform, we hope that the site's visitors will begin to discuss possible dilemmas and solutions, so as a society, we can be prepared to face these issues and work proactively rather than reactively. The theme page introduces ethical themes related to robotics, as we would like to give a holistic understanding of

the major questions in roboethics. For the tool we used to build this website, we chose Divi Builder, because it is embedded within WordPress and supported by the WPI website. It also allows no-code development and is easy to use for building a blogging website.
During the process of building the website, we iteratively adjusted the site to fulfill our goal better. There are many differences between our original plan and the final deliverable version. For the home page, we added a search bar that enables the viewers to search keywords from all pages. It replaced the searching function in our original plan, which allowed the search to be filtered by themes and domains. We made this change because a keyword search is more straightforward, and searching with filters would have been more challenging to implement. Moreover, when initially designing our website, we decided to have two drop-down menus, one for the ethical themes and the other for the robotics domains. After finishing the domain gallery page and each domain page, we decided to write a short description to introduce each theme so that the viewers can get a better sense of the ethical themes we picked and how they are related to our robotics fields. In addition, we wanted to keep the theme description short, which would not distract viewers too much. In that case, one page for one theme would be unnecessarily redundant. In the end, we decided to remove the drop-down pages for all themes; instead, we presented each theme as a card, and all theme cards are on one page. In this way, the viewers can look through all themes within one page.

Furthermore, on each domain page, one decision we made was that we put stories at the very beginning and explain the domains after. This is because we wanted to draw the viewers' attention with stories, then the viewers can choose to read more once they find the stories fascinating. Also, since all of our discussion questions are open questions, we would like to let the viewers think about the questions themselves first, and then have the option to display quotes from our resources to give them more inspiration. Considering that our quotes will only be shown as insights, a toggle feature became ideal for presenting the discussion questions since it can hide the quotes first and display quotes if needed. For the section of related themes on each domain page, we added a word cloud image that prints related themes with different font sizes based on their priority. We understood that some viewers might not understand what we mean by themes if we simply list them in the domain pages, so we provided a link to the theme gallery page for the viewers who want to learn more about them. We also allow the viewers to make comments on the domain pages, enabling them to participate in the discussions and share their

thoughts. Because of the unpredictability of robotics development in the future, the stories we created may be exaggerated or not accurately depict the future. For this reason, we also added a disclaimer on our about page, as shown in Appendix I, to avoid unnecessary misunderstandings and confusion.

Our final website, which can be found at https://wp.wpi.edu/robotethics/, introduces the project with a home page, shown in Appendix H, that describes the importance of robot ethics and the goal of our website. A dropdown menu allows the users to navigate to each of the eight technological domain pages. The themes page contains descriptions of the main ethical themes in robotics and the about page tells about the authors of our site, the purpose of the site and a disclaimer.

Conclusion

Robotic technologies are quickly advancing and becoming further integrated into society. While robots will bring increased efficiency, productivity, and utility, there are many risks and ethical implications to be considered for each robotic technology. It is critical to discuss these issues early and take preventative measures to protect humans' rights and safety. We must consider questions such as:

- How can new technologies be audited and regulated by public policy to eliminate bias and protect our rights?
- How are companies and the government using our data?
- Who will be held accountable when robots are hacked, malfunction, or used to cause harm?
- How will robots shape social interactions, the workplace, and government power in the future?

We hope that our website will help anyone interested in robot ethics explore a wide range of ethical concerns in different application domains. The website should serve as a starting point for further research and discussion. In the future, our stories could be improved by getting feedback from people specializing in creative writing. To gain more insight into how effective our website is as an educational tool, future work may include a survey that asks participants questions before and after viewing the website to determine what new information they learned. It could also be useful to conduct a survey about the website design to find ways to improve our

user interface and make the website more accessible. The website could also be expanded in the future to include more application domains. We selected eight domains to include in our current version of the website. However, there are many more fields of robotics such as outdoor, entertainment, and education robotics.

This project presented different perspectives on robot ethics in a variety of application domains. The story-driven web pages provide engaging introductions to these topics that are accessible to even those without an engineering background. Our goal is to initiate meaningful conversations about robot ethics so that people become aware of the ethical implications of new robotic technologies, take preventative measures to minimize risks, and develop solutions that consider all parties involved. With the development of robotics, there will be more expected and unexpected ethical challenges. We hope our project will continue to inspire people in the future.

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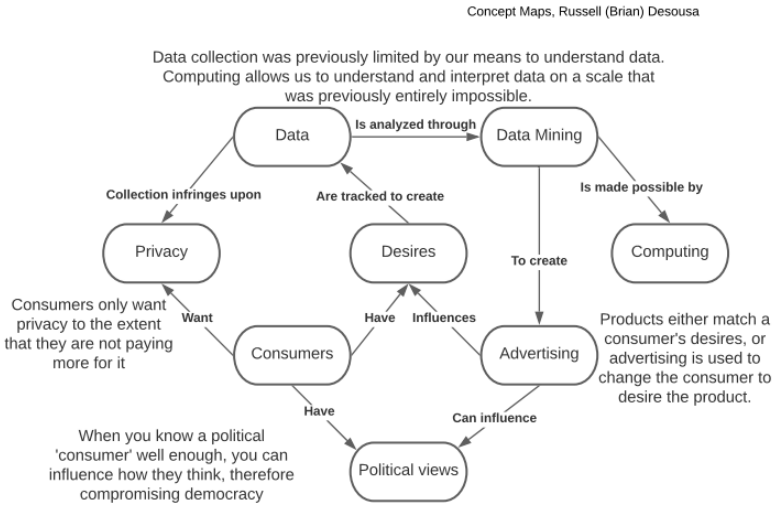
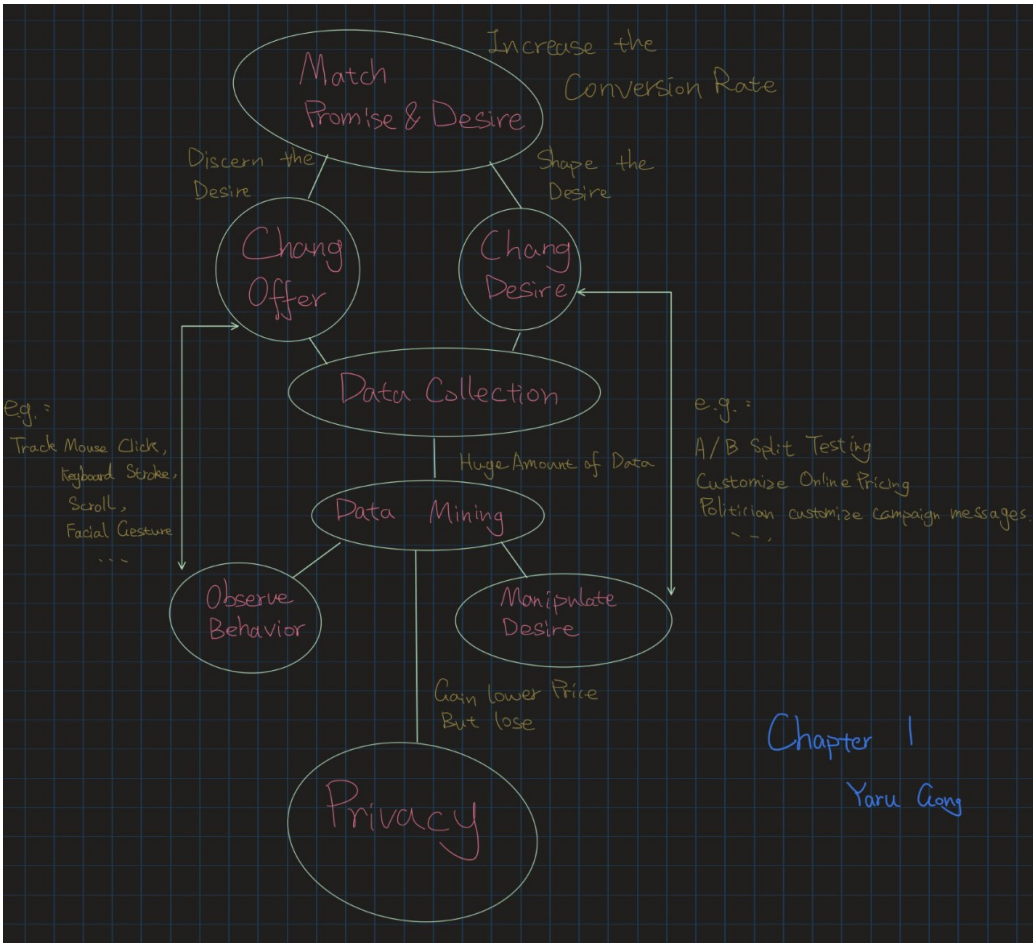
Appendix A - *Robot Futures* Concept Maps

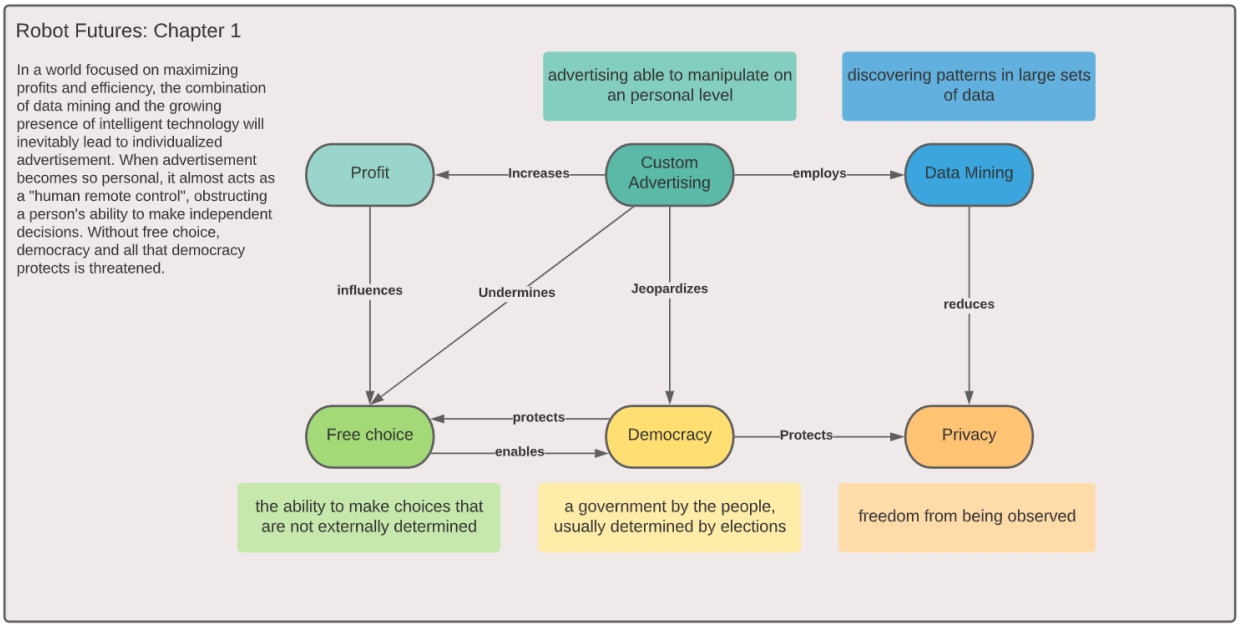
Chapter 1

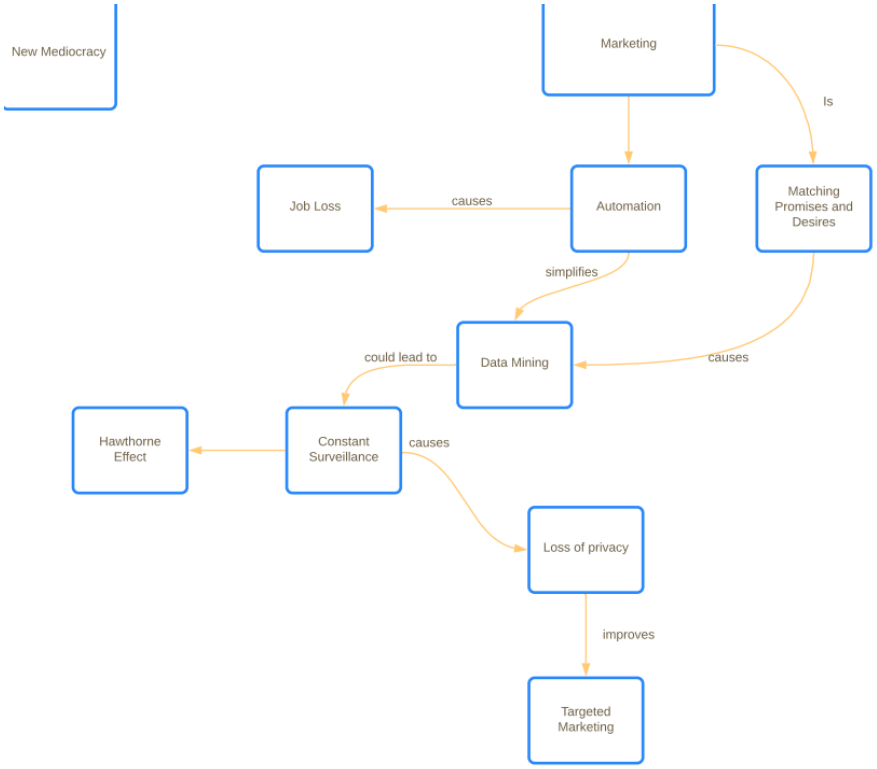


Chapter 1: New Mediocracy

Explores how data is collected, and how the data that is collected is then analyzed in order to better sell products. Relates to robotics in that, this level of data analysis is only possible through computing advances, and that in the future, advanced intelligence could control politics to the point of essentially negating democracy.

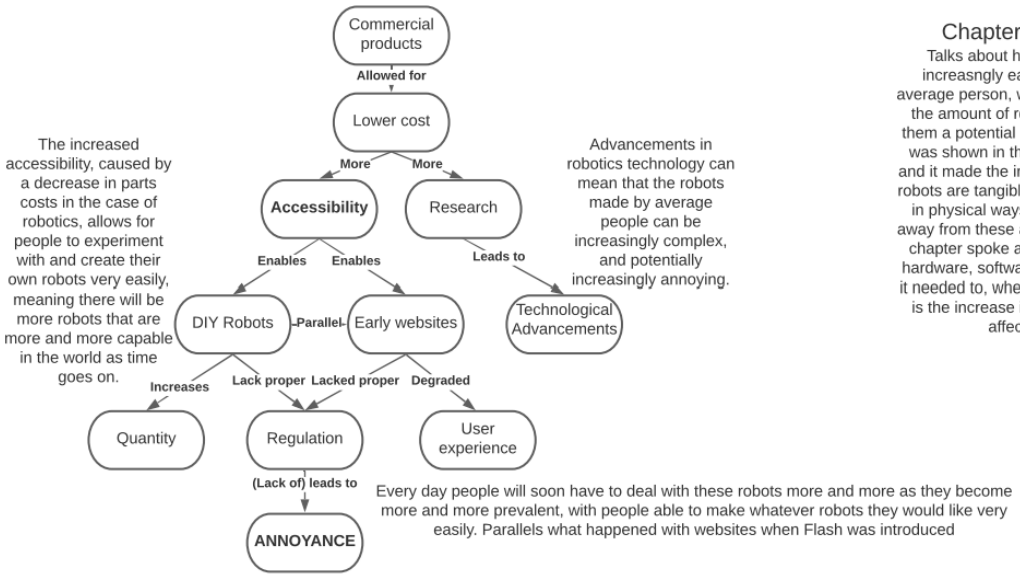






Chapter 1 of *Robot Futures* imagines a world where marketing has become an automated task. It is discussed how as marketing becomes automated, data mining will become more widespread so that adds can become more targeted, shaping a person's desire perfect with whatever 'promise' a company can make. Once data mining is perfected and all actions of a consumer are tracked to find the best way to target them, we also experience a loss of privacy and in turn freedom. The Hawthorne effect is how someone's actions are changed because they are aware they are being monitored. I wonder if data mining could shape how people act on a day to day basis because they know they are being watched. Like described in the chapter, will people laugh at a joke simply because it is supposed to be funny rather than of their own free will?

Chapter 2



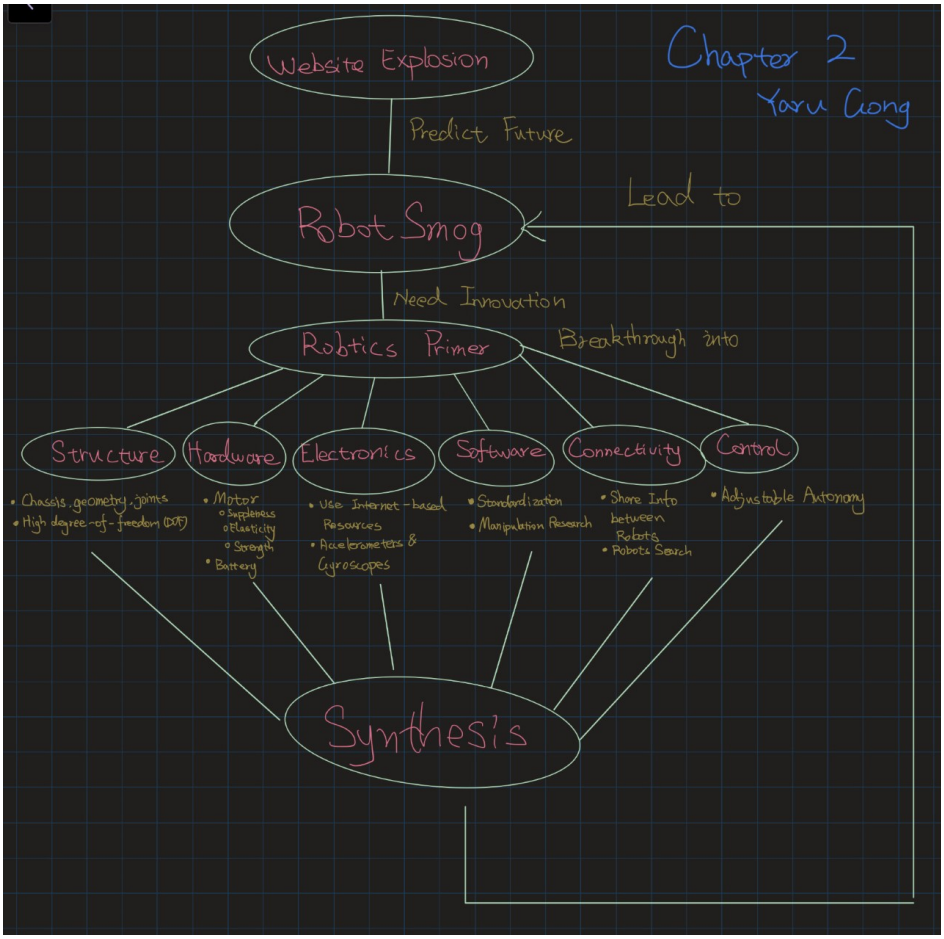
The increased accessibility, caused by a decrease in parts costs in the case of robotics, allows for people to experiment with and create their own robots very easily, meaning there will be more robots that are more and more capable in the world as time goes on.

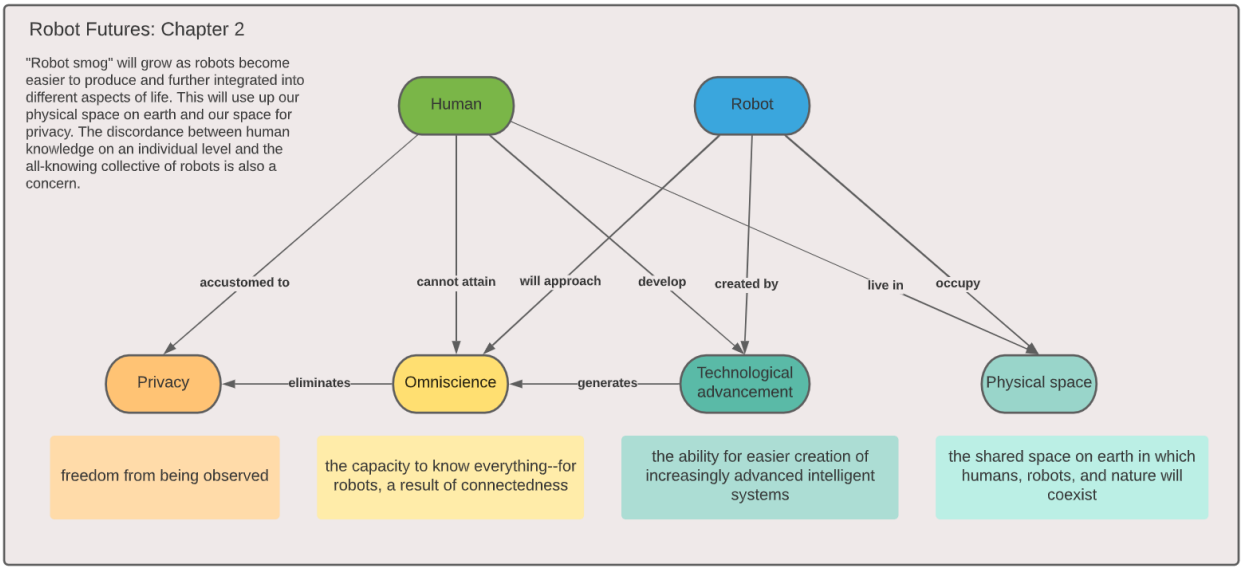
Advancements in robotics technology can mean that the robots made by average people can be increasingly complex, and potentially increasingly annoying.

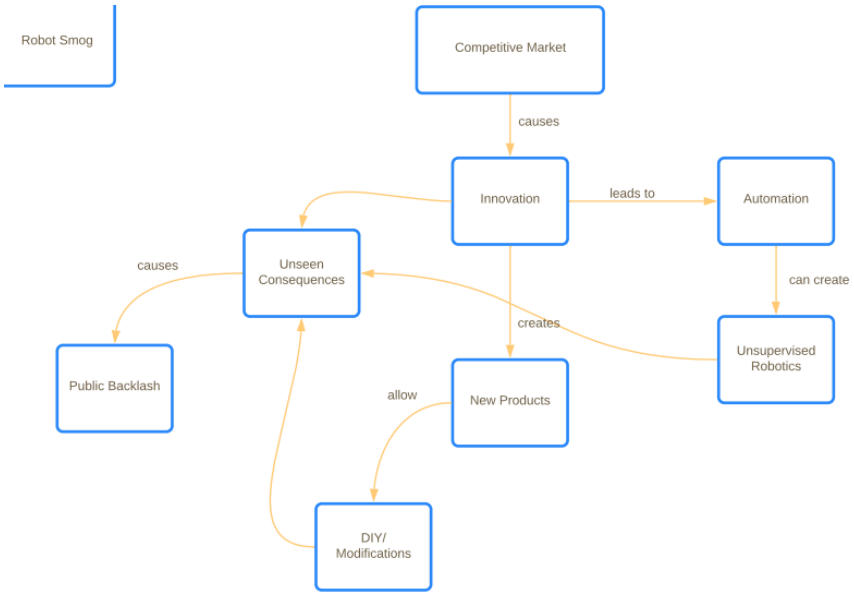
Every day people will soon have to deal with these robots more and more as they become more and more prevalent, with people able to make whatever robots they would like very easily. Parallels what happened with websites when Flash was introduced

Chapter 2: Robot Smog

Talks about how robots are becoming increasngly easy to make, even for the average person, which leads to an increase in the amount of robots in existence, making them a potential issue in day to day life. This was shown in the past with early websites, and it made the internet less usable, however robots are tangible things that effect the world in physical ways, meaning you cannot get away from these annoyances. Personally, this chapter spoke at greater lengths about the hardware, software, etc. advancements than it needed to, when the most important aspect is the increase in robots and how they will affect day to day life

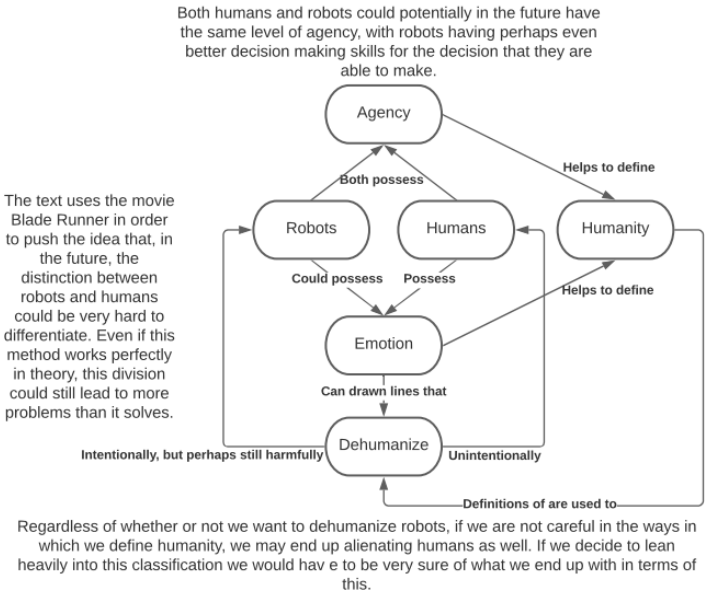






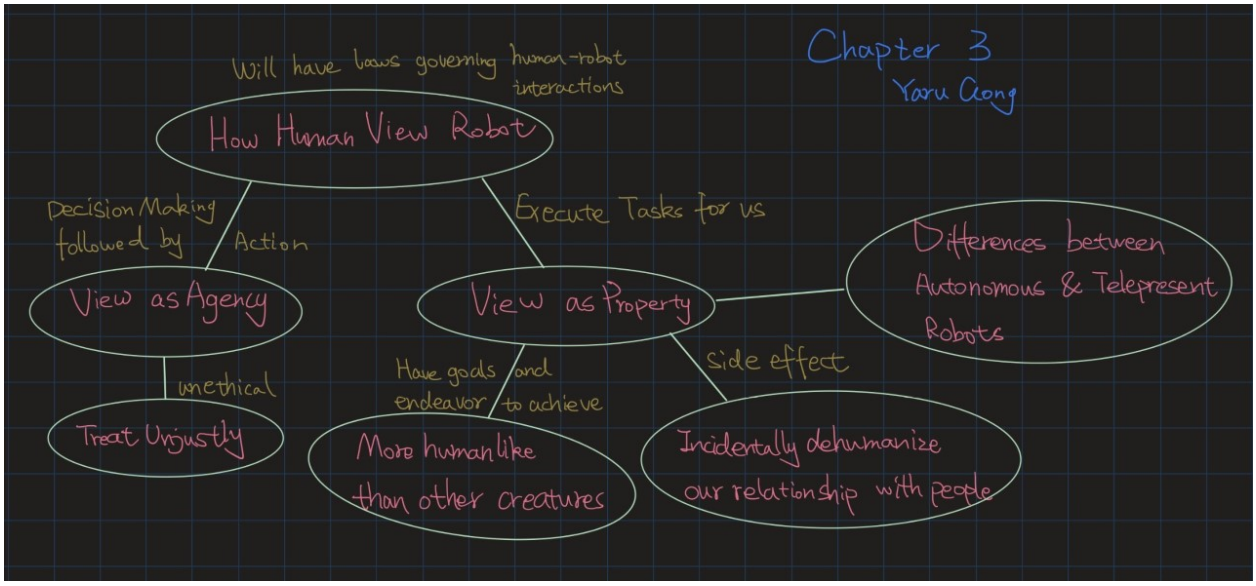
Chapter 2 ofRobot Futuresexplores the consequences of innovation and public modification. In the chapter after a business man strived to create the optimal childrens' toy we see his innovations consequences on the general public. His toys that have been left out now roam freely and his design has been modified by others in order to create robots that trap you if you make eye contact. This chapter begs the question should a creator be held responsible for the unforeseen consequences of his creation, and is it possible to protect the public from innovation?

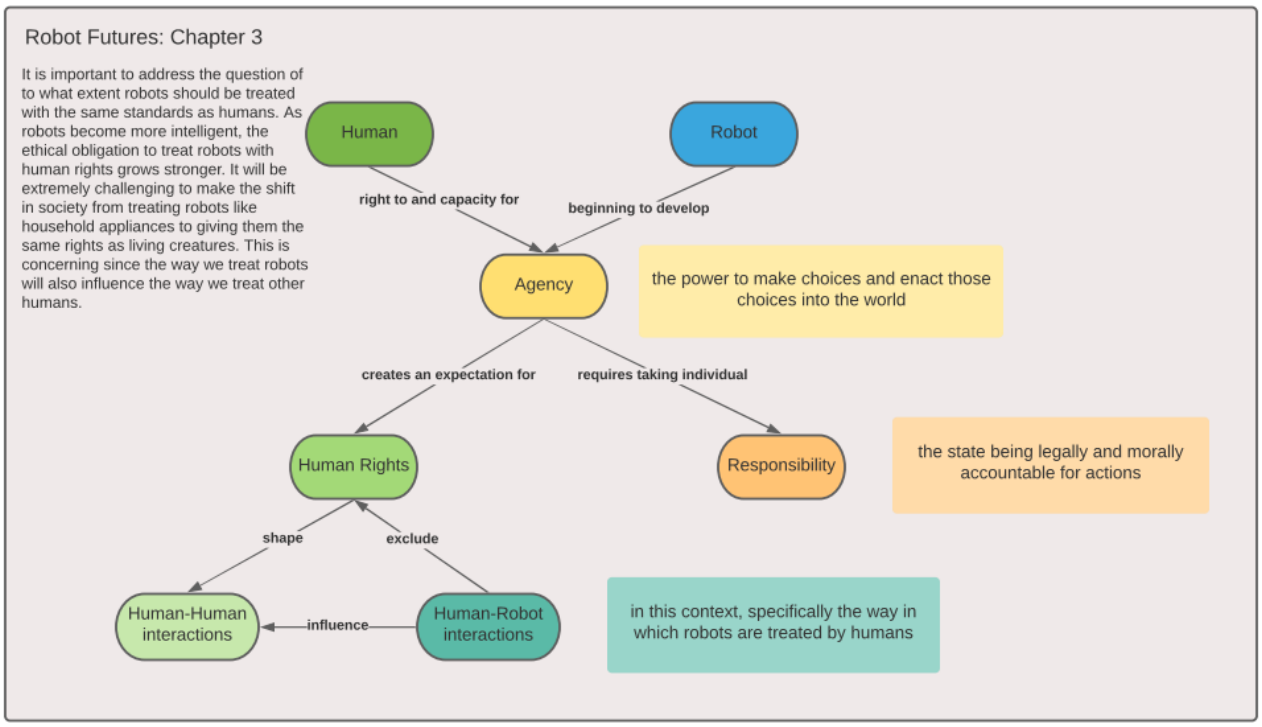
Chapter 3

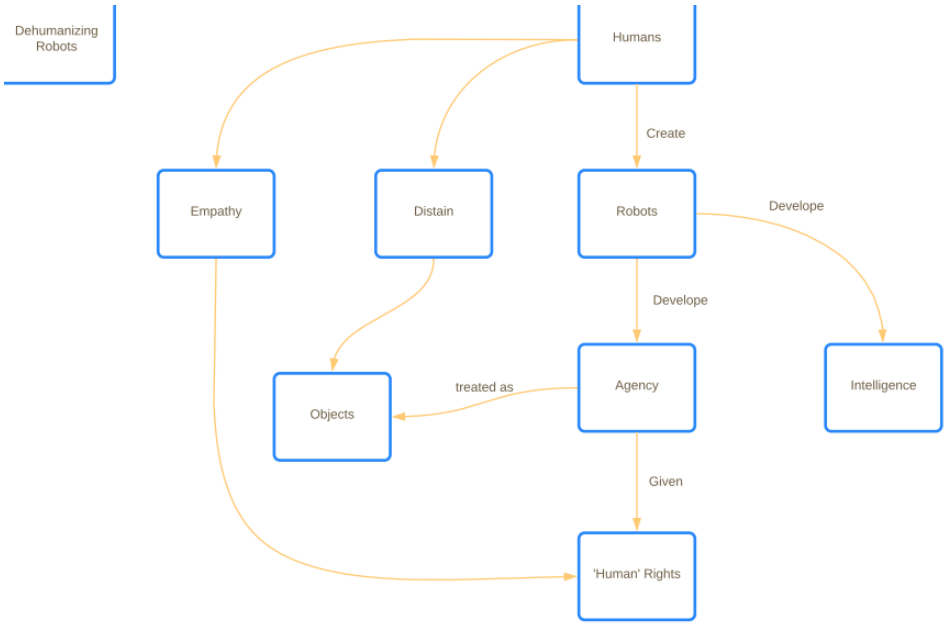


Chapter 3: Dehumanizing Robots

This section of the text was more difficult to put into this concept map, so I will put the other things I would like to say on the topic here instead. The premise of this section relies on the assumption that we as a society need to dehumanize robots in order to guide human-robot relations. If robots are, in any metric we choose, equivalent to us as humans, why is there a need to dehumanize them? It will become harder and harder to keep these 2 groups seperate without alienating members of humanity that do not match the exact description we set for it. There may be humans who have less emotion than robots, do we then say that they are robots?



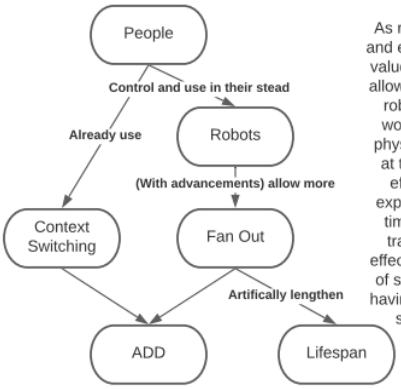




Chapter 3 of*Robot Futures*dives into the questions surrounding artificial intelligence (AI). As of today there hasn't been an AI developed that can act autonomously or obtained the emotional and social intelligence to pass for human. However once an AI has reached a point of having agency and can act entirely autonomously society will be faced with many new ethical dilemmas. The very idea of "human rights" will come into question because humans will not be the only entities that will exist and be able to question and interact with our society.

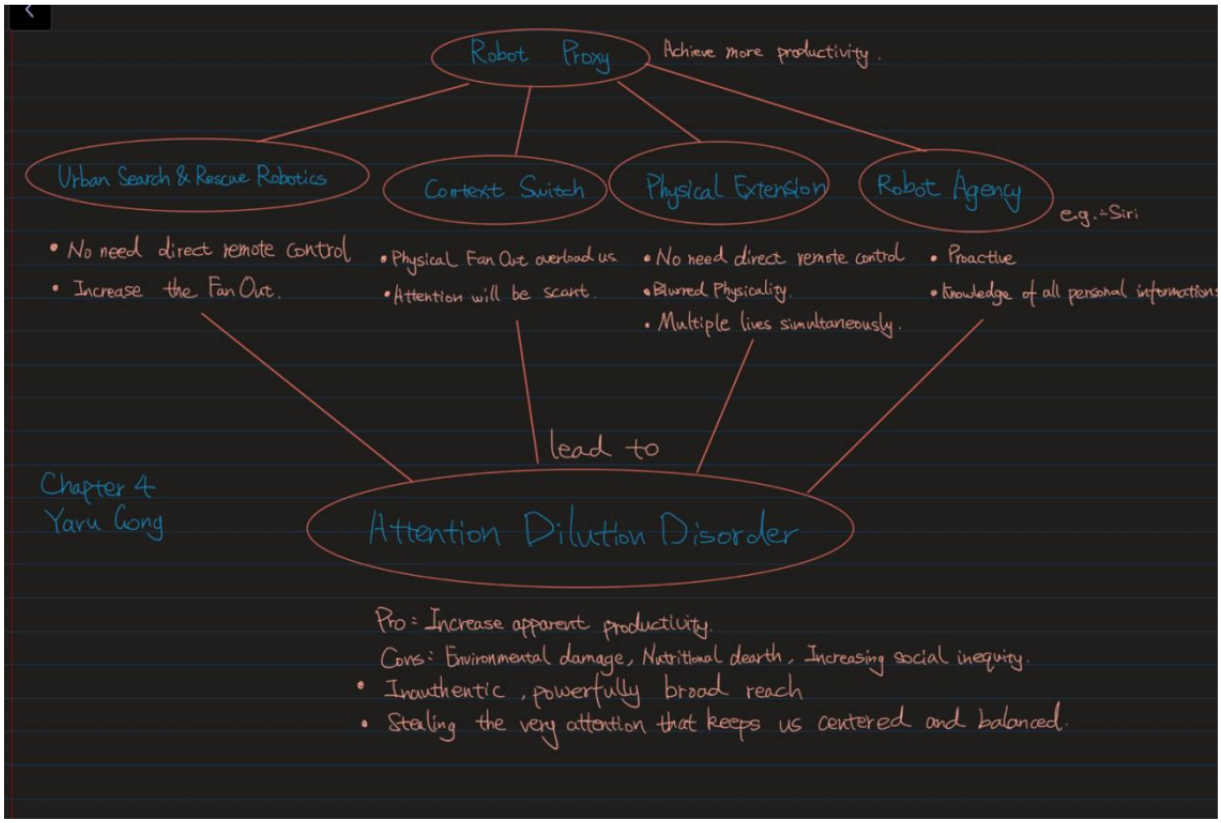
Chapter 4

People already context switch with things like texting and email, allowing us to hold many conversations, even at once, with many different people. In the future this could apply to our 'physical' relationships as well, where we are physically with multiple people at once via multiple robots



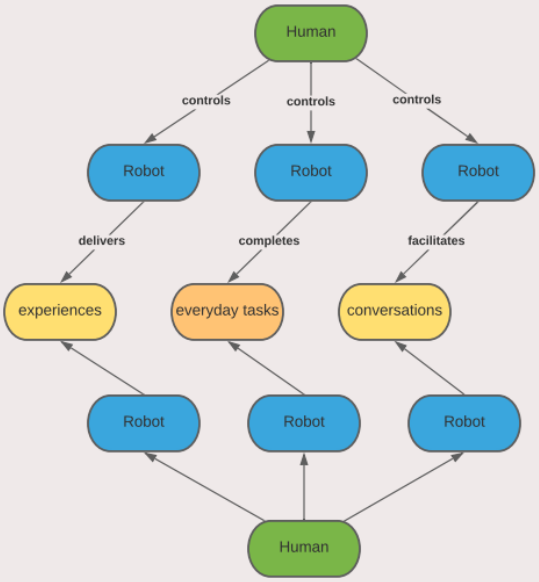
As robots get more advanced, and easier to control, the fan out value could increase drastically allowing people to control many robots at once. This is what would allow for people to be physically with multiple people at the same time. This could effectively allow people to experience more at any given time, as they aren't waiting, traveling, etc., which could effectively increase the lifespan of someone because they are having more experiences in the same amount of time as someone else.

Chapter 4: Attention Dilution Disorder
As we, in our current day to day lives context switch very often in order to talk to different groups of people, or talking to people for different reasons or under different contexts, it makes sense that we would continue to do this in the future. However, with lifelike humanoid robots that can artificially extend our reach, this could be taken to a whole new level. Our attention could be spread even thinner than it already is as we experience mutliple social situations at the same time in person as opposed to online.



Robot Futures: Chapter 4

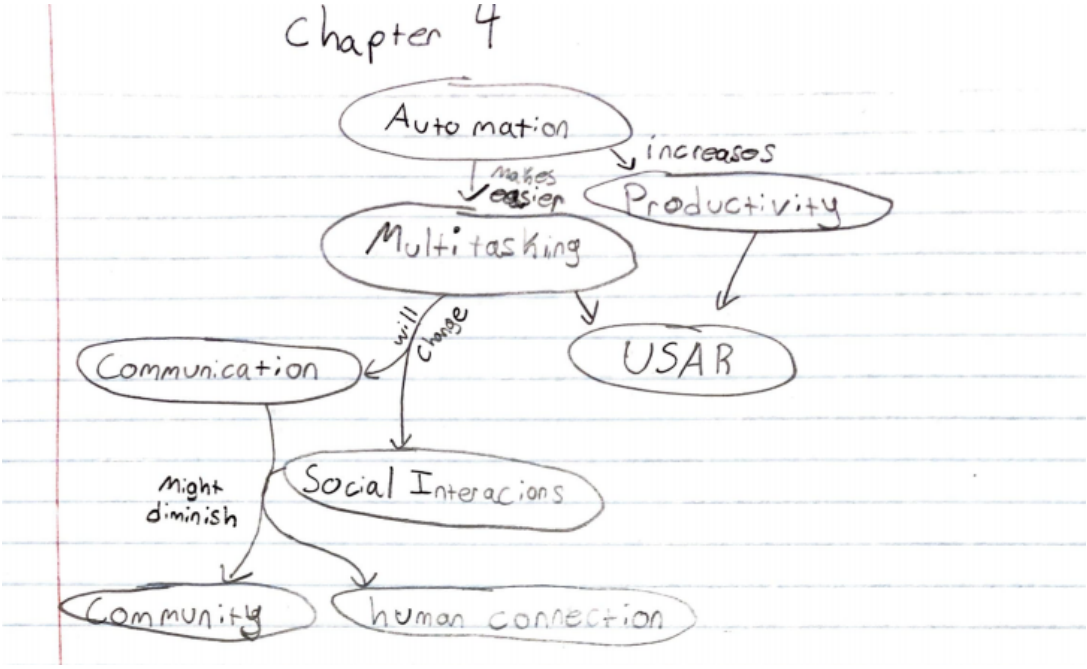
As robot autonomy improves and research in USAR robotics continues the possibilities for human "fan out" increase. Humans will be able to experience many different things at the same time through robots. The robots will take care of the "boring" tasks allowing humans to pick and choose what is important enough to experience in real life. This also creates a situation where one person can live multiple lives through multiple robots at one time.



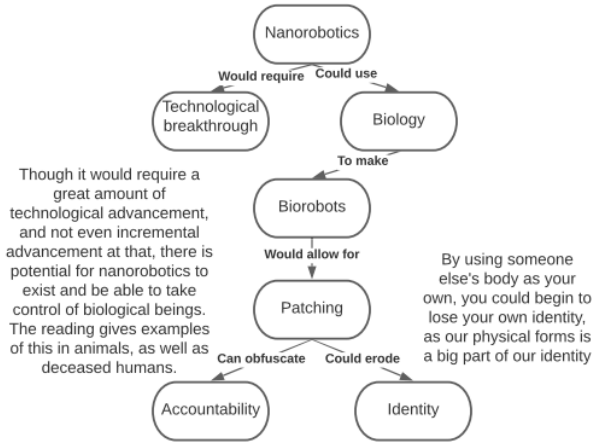
Fan-out: the number of robots a person can control at once

audjustable autonomy: robots seamlessly switch between autonomous mode and asking for human input

interactions become robot to robot instead of human to human



Chapter 5



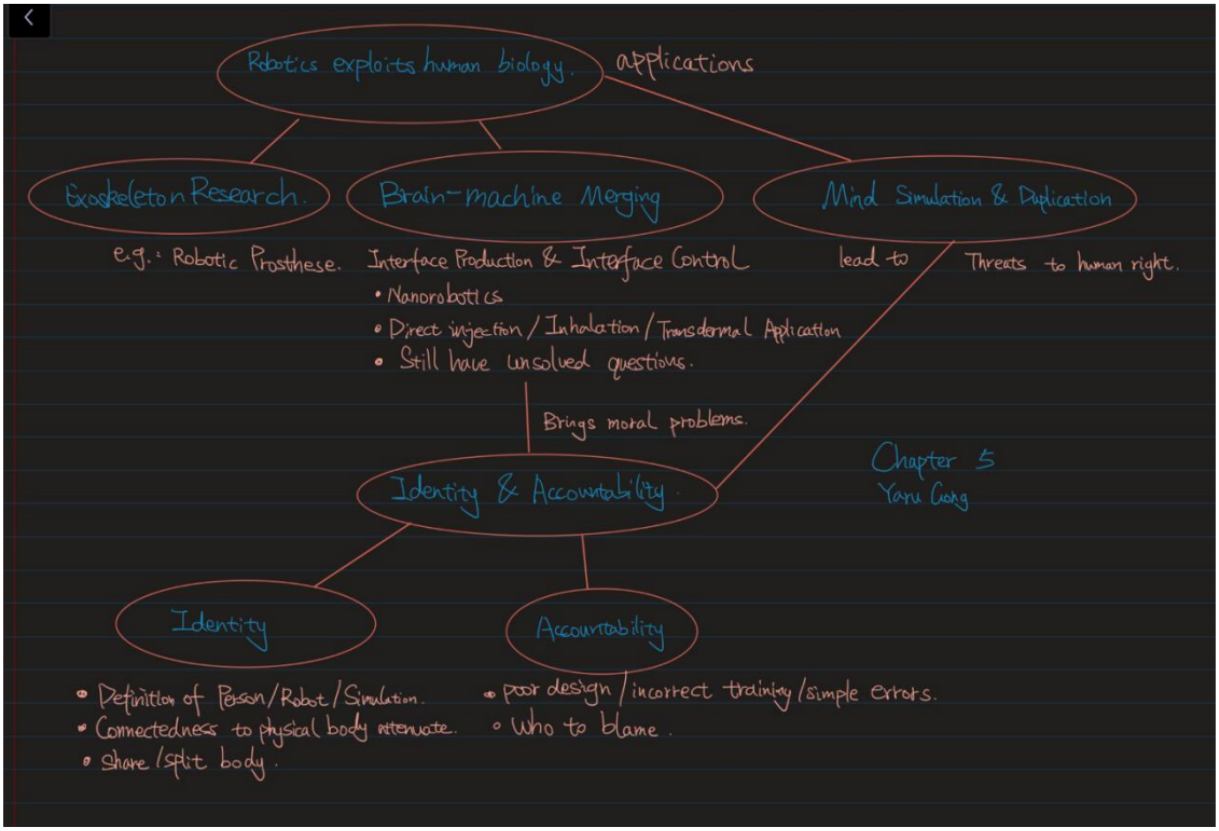
Though it would require a great amount of technological advancement, and not even incremental advancement at that, there is potential for nanorobotics to exist and be able to take control of biological beings. The reading gives examples of this in animals, as well as deceased humans.

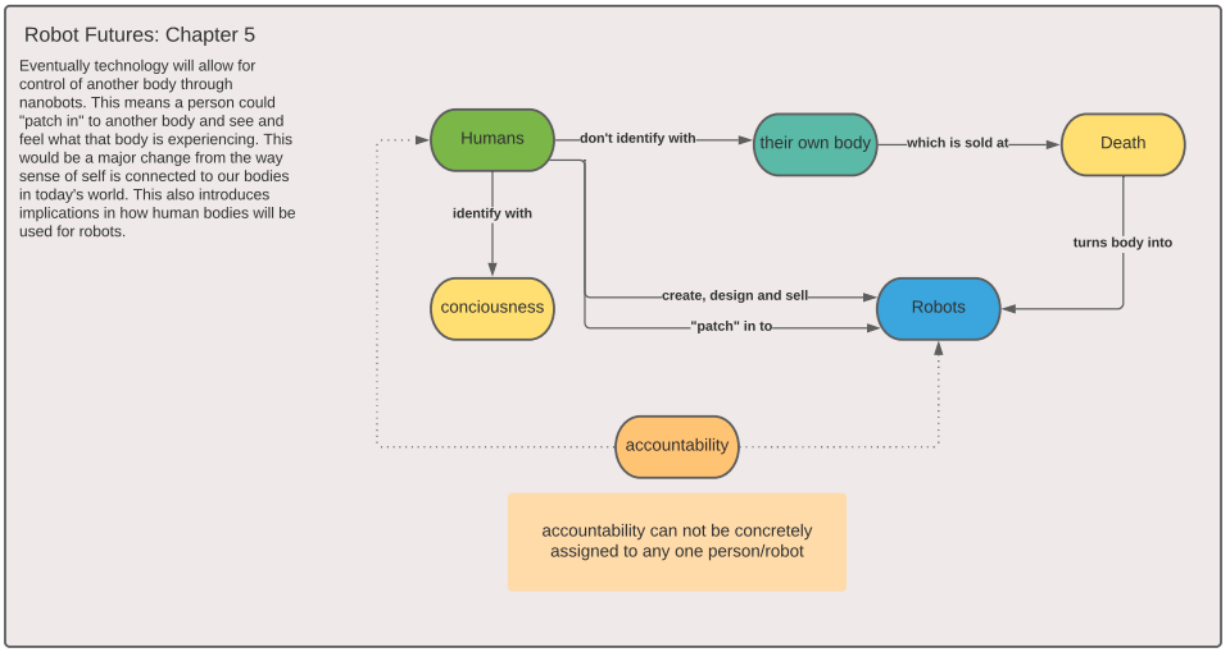
By using someone else's body as your own, you could begin to lose your own identity, as our physical forms is a big part of our identity

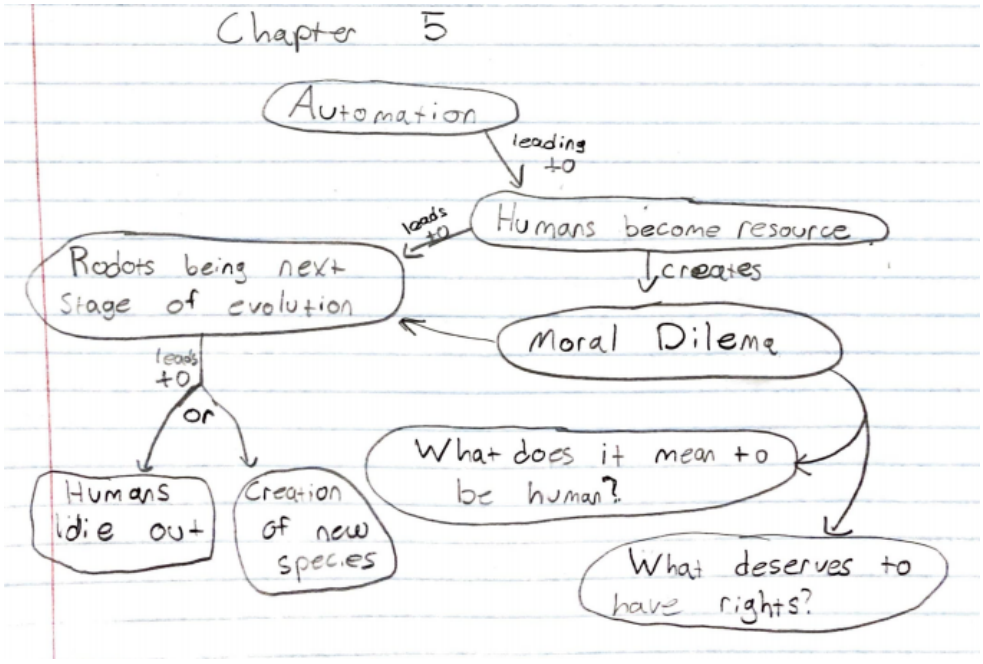
Due to the nature of these robots, and the complexity of such a situation, it could be hard to pinpoint accountability in the situation that something goes wrong.

Chapter 5: Brainspotting

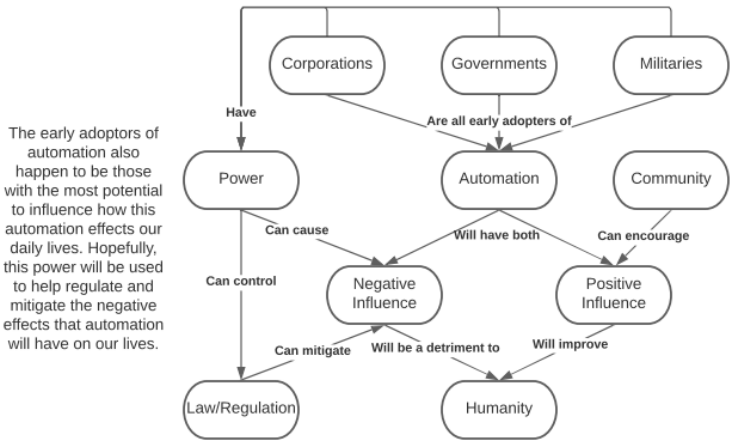
This, to me, was the most sci-fi esque, and also the most bleak chapter of these readings. The second example, which goes into more detail the process of how a company would acquire bodies, and how the process might work, was interesting and disconcerting. I would hope that this won't be the case in the future, if this kind of technology is even feasible, or more importantly, economical, as that will most likely be the deciding factor.




Robot Futures: Chapter 5
Eventually technology will allow for control of another body through nanobots. This means a person could "patch in" to another body and see and feel what that body is experiencing. This would be a major change from the way sense of self is connected to our bodies in today's world. This also introduces implications in how human bodies will be used for robots.
Humans
don't identify with
their own body
which is sold at
Death
identify with
turns body into
conciousness
create, design and sell
Robots
"patch" in to
accountability
accountability can not be concretely assigned to any one person/robot


Chapter 5
Automation
leading to
Humans become resource
leads to
creates
Robots being next stage of evolution
Moral Dilema
leads to
or
What does it mean to be human?
Humans die out
Creation of new species
What deserves to have rights?

Chapter 6

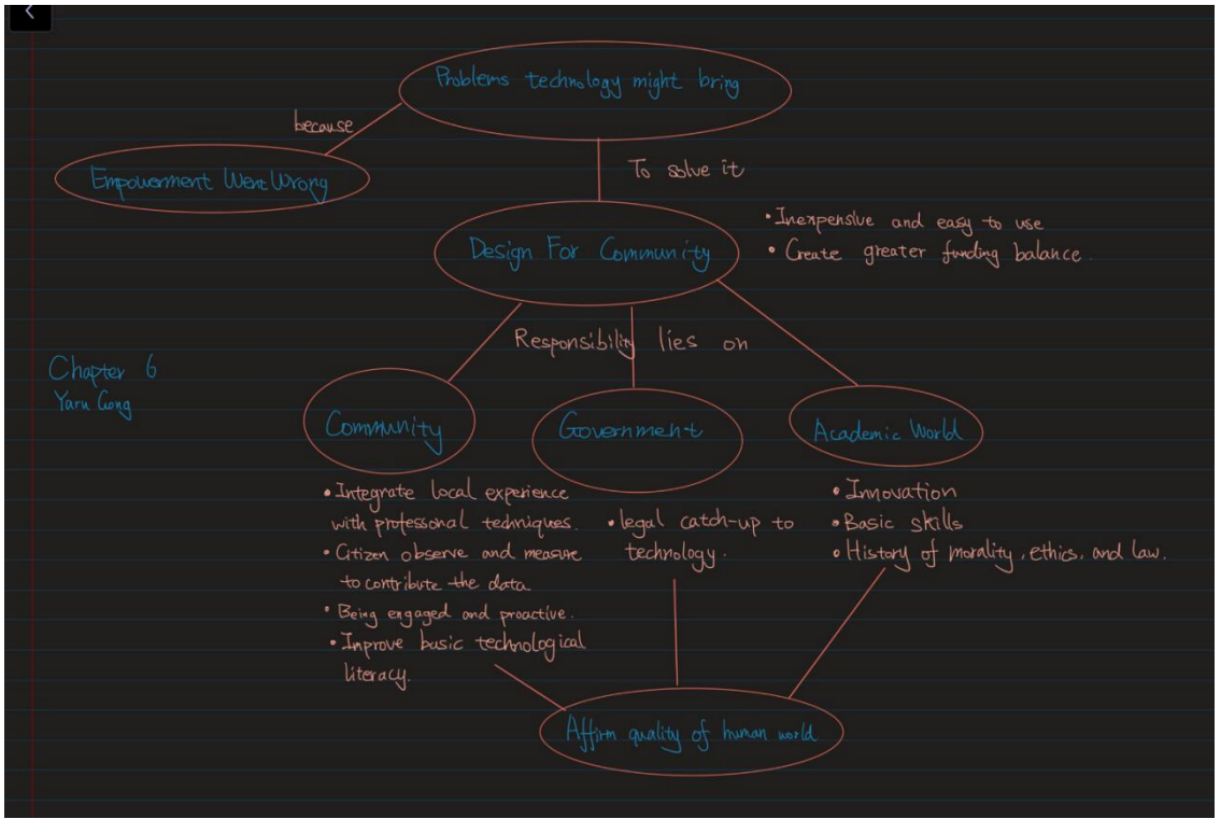


The early adoptors of automation also happen to be those with the most potential to influence how this automation effects our daily lives. Hopefully, this power will be used to help regulate and mitigate the negative effects that automation will have on our lives.

In addition to the large groups that hold power, people in large numbers hold power too, and it is important that communities will do what they can as well to help influence and encourage the positive aspects of automation while trying to deter the negative effects.

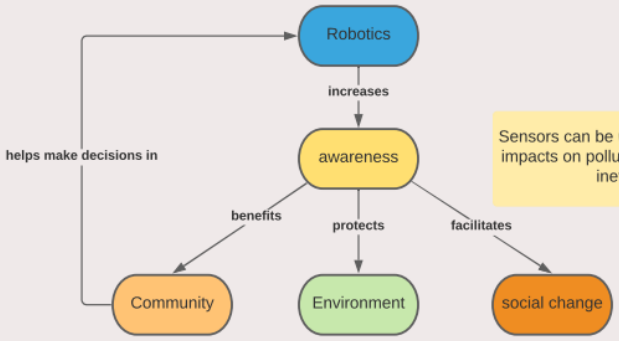
Chapter 6: Which robot future? A Way Forward

As a conclusion to the previous readings, this chapter mostly talks about the future of robotics as a whole and how this will affect us in the future on a more grand scale. The biggest takeaway from this for me is that, we as people need to do everything in our power to ensure that the future of robotics is also a future that is beneficial to all of us as well. This is not news to me, but it is important nevertheless.



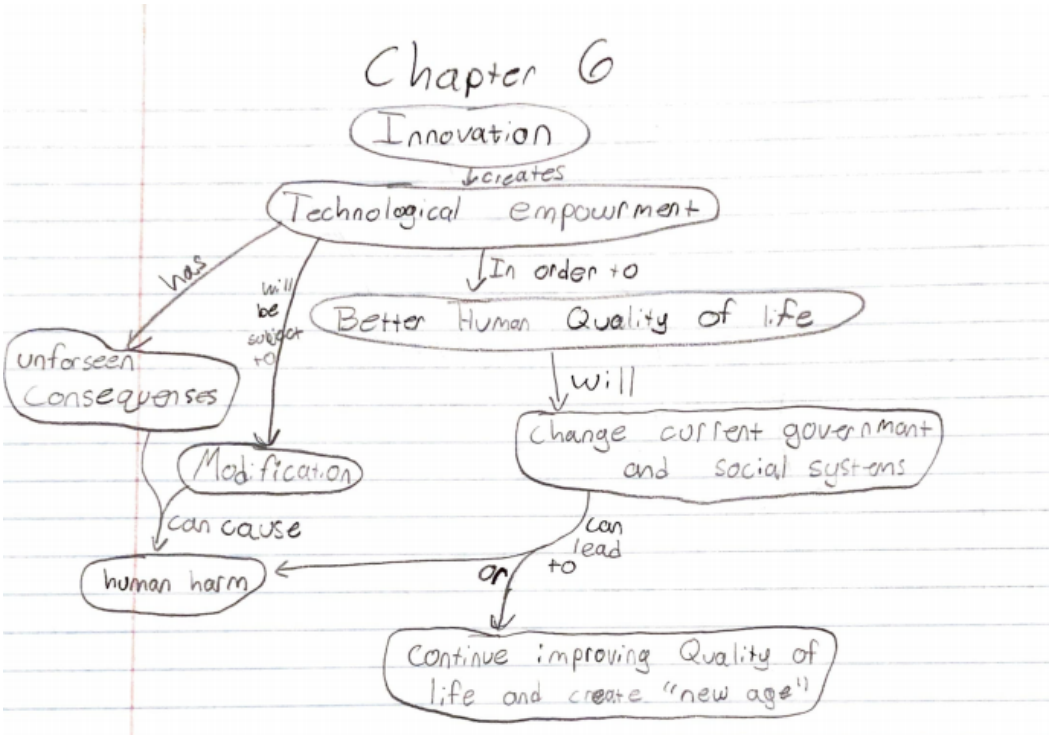
Robot Futures: Chapter 6

There are opportunities for innovation in robotics to have a positive impact on communities and social issues. For this to happen, the social impact of innovations needs to become part of the funding decision. Robotics can also be used to raise awareness of local pollution, energy inefficiency, and traffic density. For robotics to have a positive impact in future communities, engineers need to be more educated in ethics and outside views (ie. people outside the corporation or technical research) need to be considered in the decision making processes.



Sensors can be used to measure individual impacts on pollution, traffic density, energy inefficiency...etc.

people should contribute to decisions made in robotics that will impact their communities



Appendix B - Table of Themes & Domains

	Humanoid Robots	Industrial Robotics	Domestic Robots
Human rights	Should these robots have the same rights as humans?	A large concern with robotics entering the robotics industry is how it will affect the people whose jobs the robots are taking. As jobs get taken by machines companies might become more efficient and save money, but in the process jobs are lost. On the other hand, as robots take over new jobs are created for the robots upkeep, and new fields develop more jobs that people can explore and advance. Are industrial robots taking people's jobs bad or an opportunity to progress?	How will this affect people's attitude towards robots and how robots will be treated? Additionally, is it right to have a robot raise a child?
Government	Should these robots have protections under the law?	What will governments do to ensure that people displaced by industrial robotics in their jobs will still have a source of income?	Could the robots be hacked and used to spy on individual households?
Accountability	In the event one of these robots causes a serious issue, will they be held accountable themselves, or will that blame fall to someone/something else?	If people are still working alongside robots in the future, and an accident occurs, will the human worker be more at fault?	The robots that care for children will inevitably have an impact on their development, and if this has negative impacts, are the parents at fault or is the robot/company?
Safety and Security	If these robots are used commonly enough around other people, they should be safe and secure enough that there is no risk of them harming someone.	When there is robot/human interaction, how much will the safety guidelines of existing workplaces adapt to this, and will it be enough?	Would these robots be responsible for the safety of children present in the house? Could these robots accidentally start a fire in someone's house?

Transparency/ Explainability	Since humanoid robots will all probably look quite similar but have different directives, these directives should be transparent to people.	Companies should be transparent about what processes they plan to automate	Any shortcomings or potential problem-producing quirks of servant robots should be made very apparent to consumers in order to prevent accidents.
Fairness and Non-discrimination	How will companies that mass produce robots make decisions about the race, gender, ethnicity..etc that these robots appear as? How will these decisions influence the treatment of people that these robots are modeled after?	Will the people displaced by these robots be displaced based on discrimination, such as non-white workers being displaced at higher rates than other workers?	If there are robots that end up teaching people, any inherent bias from the designers could end up influencing others, and perpetuating those biases.
Religion	Would 'artificial' people be accepted into religion? Would a machine with agency be seen to have a 'soul'? Could the 'perfect' person created with technology be seen as a deity?	Robotics are revolutionizing the industrial market and are both eliminating jobs as well as creating new jobs in order to maintain and manage the new automated process. If religion turns down the path of avoiding or simply not partaking in the technology of robotics it will be interesting to see if people will refuse to work jobs with or managing robotic systems	Will more religions start to implement rules that limit technology within homes and personal lives like the Amish?
Identity	Are humanoid robots more recognized as human or robots? Should we use gender based pronouns when talking to robots or call them by it or that? Does using gender based pronouns help humans empathize with robots?	As people lose more jobs to industrial robots the populations work identity will also most likely change. People will not work as much with their hands in a factory rather they will work in more management like positions overlooking other people or more robots	Will having robots to do things domestically free up time for people to work on hobbies and etc? This could potentially lead to a change in identity for people as they are able to engage in more things.
Human control of technology	Can humanoid robots control other robots?	Should Industrial robots be controlled fully by companies?	Who can control the domestic robots? What if two people give different orders to the robots? For visitors, can they give orders to the robots as

			well?
Professional responsibility	Should the designers make humanoid robots as much similar to humans as possible, or make some distinguishing mark on humanoid robots to prevent that?	When designing industries robots, will designers take more from companies or from communities into consideration?	How could developers and designers prevent their robot servants from making mistakes, if it happens, what could robots do to make up?
Promotion of Human Values / Public Interest	A robot doesn't have the same needs, and would not experience the world in the same way that we do. How would we keep them 'on the same page' as us when it comes to them being able to understand us.	For the industrial robots, do they promote human values or demote, since they replace human's jobs? Do they let people do more meaningful work, or do they erase the meaning of work?	For robots that could potentially be somewhat of a role model for children, would they possibly be even better at some parents at getting across the importance of human life, and other important topics?
Anthropomorphization	By anthropomorphizing robots and not treating them in the same way we treat people, people could potentially start treating others how they treat these robots (worse).	The anthropomorphization of industrial robots can make people more tolerant to the mistakes robots made.	Which direction should we go in the anthropomorphizing of these robots? It is better in this case to either lean fully into humanizing them, or fully into dehumanizing them.

	Distributed Robotics Systems	**Outdoor Robotics**	**Biorobotics**
Human rights	Since these robots are all linked and collecting massive amounts of data, to what extent do people have a right to privacy? What can be done with the data collected about a person?	For robotic systems that are designed to, say, harvest resources, how will people ensure that this is done ethically. What happens if these robots, for example, decide to harvest on indigenous land?	To what extent would human bodies be used for research in this field?

Government	How does custom advertising, using data collected from robot networks, limit free choice needed for democracy? Does the government have a responsibility to protect the privacy of the people?	By making the process of harvesting resources easier, we will inevitably want to harvest more resources. Will there be proactive government involvement to ensure that we do not degrade our planet at a faster rate than we already do? Will there be traffic laws for these robots to abide by?	Should it be legal to create Biorobots that are built based on human bodies? Can people decide to give up their bodies and contribute to Biorobots? Can companies buy human bodies for research purposes?
Accountability	When custom advertising manipulates people almost as a human remote control, are these people still responsible for their actions under the manipulation of an advertisement, or should an advertiser be held responsible?	Who will be held accountable for air collisions between flying robots?	Who will be held accountable if biohacking leads to illness or death? Will the government regulate approved and unapproved biohacking procedures?
Safety and Security	Could this sort of analysis be used to identify people who are going to commit crimes before they even commit them?	Flying robots may interfere with air traffic or fall out of the sky and hurt someone, especially in the case of a collision.	The design and function of these systems should be such that they are as safe as possible for the user and for others.
Transparency/ Explainability	Do people always need to be informed when data is being collected on them?	For robots that will potentially be on the property of people, the purpose of the robots should be stated, and the property owner should have the ability to deny access to their land in cases.	Will companies be transparent about the extent to which they are using human/animal testing or parts in the making of these robots?
Fairness and Non-discrimination	Could this data be used in a way that is harmful to under-represented parts of the population?	What areas will these robots populate the most? How will this impact noise, pollution...etc in these areas?	How will biorobotic systems be distributed to people who need the technology but may not have the monetary means to own it?

Religion	Will these systems be seen as "god-like" because of their omniscient, all-knowing nature? To what extent are these systems a controlling presence in the universe if they know almost everything and use that knowledge to manipulate humans into behaving in certain ways		Would body augmentation be banned by certain religions? Could body augmentation be seen as the next stage of evolution?
Identity			For Biorobots who are built on human bodies, do they still recognize themselves as human? To what extent, like how many percent of their bodies are made by robots, they are not recognized as human anymore?
Human control of technology	When collecting data, will they be regulated that some important data should not be searched?	Who can control outdoors robots, any human on the street or just its owner?	Should biorobots be controlled by another human or belong to its body?
Professional responsibility	What are developers responsibilities when collecting users data?	How could designers and developers prevent their robots bothering humans outdoors?	What kind of responsibilities do those developers have when building robots based on human bodies?
Promotion of Human Values / Public Interest	How will these systems shape culture and values of humans through targeted advertising?	For robots that are going to be in public, in numbers, it is important that we keep the best interest of people in mind in the ways that we allow these robots to act and interact with the world.	If a Biorobot can do everything better than human, what are the values of being human? Are there only emotional values left?

Anthropomorphization	The anthropomorphizing of other technologies may make people react less to invasive and potentially harmful technologies.	By anthropomorphizing the outdoors robots, people are likely to treat robots better. This might decrease the potential damage rate of outdoor robots, and lower the budget caused by damaging the robots on purpose.	

	Biomechatronics	**Healthcare/QOL**	**Military Robotics**
Human rights	Will biohacking affect someone's personal rights? will people become discriminated against for having modifications, or will people without modifications be discriminated against?	Do patients have the right to ask to be handled by people only? Health care can already be very alienating and 'cold', will this make things worse for patients?	Are there types of robotics that aren't fit or are too inhumane to use in war? Who decides? Can robots be used to keep order in an area or are they unfit?
Government	The government needs to update the law related to Biohacking and corresponding sentences. Will any biohacking be considered dangerous enough to be illegal?	How much will the price and usage of these robotic surgeries/care/etc. be regulated?	The government should be as proactive as possible with the regulation of technology that will be implemented in the military.
Accountability	Will biohacking that could save someone's life become mandatory? will only people who can afford the modifications have access? Will the government regulate body modifications?	When something goes wrong during this process, who will be at fault? Will the surgeons working with surgical robots, or the designer of the robots be in the wrong if the robot makes a mistake?	In the U.S.A. there are no autonomous robots that take human life. If a machine is to take human life it must be controlled by a person who can judge the situation as well as its morality. Will there ever be a point where robots will be able to judge if a person should live or die? Who is held accountable for these deaths?

Safety and Security	Parts of people that have been modified may be subject to outside control	Could these robots be hacked? What happens to a hospital run by robots when the power goes out?	How will the military uses of robots be kept regulated and safe? Even if the robots themselves do not have any safety issues the way robotics could be applied to military situations can put people at risk. In military scenarios could we trust a robot to be able to distinguish between enemies and innocent civilians?
Transparency/ Explainability	How would you be able to tell if someone is using an altered part of their body to say, spy on you	Will patients be informed of whether an operation will be done by a human surgeon or robot?	Should robotics follow the same protocol of transparency as other military technologies? There are many military technologies that are kept secret in order to avoid enemies being able to exploit weaknesses, but if robots are protecting people should they have a right to understand all of the robots specifications?
Fairness and Non-discrimination	How will people who are bio hacked affect opportunities? Can they compete in sports? Who will have access to biohacking procedures?	How will this impact the affordability of healthcare?	How will autonomous robots be able to distinguish enemies from allies and civilians? Will the robots be used in battle situations or to police people?
Religion	Would religions prefer to have a human operate or perform medical procedures for automated machinery?	Will people forgo medical procedures for religious purposes because they are performed by robots? Will people easily trust medical machines or will more people prefer to use human doctors for operations and other procedures?	

Identity	For people who get biohacked and could not freely control their bodies anymore, are they still human?	Are Health care robots more like doctors, nurses, or just assistance? What if the robots have different opinions when taking care of patience?	How will this affect the identity of the people who create these robots? The people who build them may feel guilt for things the robot does when it is under the control of the military or the robot may be used in ways that it was not initially intended to be used.
Human control of technology	When people get biohacked, can they still control their bodies? If not, who will take over, human or robots?	Are healthcare robots more controlled by patients or doctors?	Do military robots listen to humans from other countries? What if it's not during the war?
Professional responsibility	How could people who design related technology prevent illegal biohacked?	For professional experts in medical areas, what are their responsibilities to develop healthcare AI?	What responsibilities do the military have when requesting, or ordering the robots? During the war, what comes first when the order needs to be sacrificed between humans?
Promotion of Human Values / Public Interest	What if it cause the discrimination between people who are biohecked and people who are not?	People let the healthcare robots take care of patiences. Will that be better or worse to the mental wellness of the patient? Will their families spend less time with them since the robots can take over everything?	Whose public interest do we have in mind when we deploy these technologies? The nation deploying them, other nations, the world as a whole?
Anthropomorphization	Robots that are used as land mine removal, for example, often get anthropomorphized, and are mourned by soldiers when they break.	Anthropomorphized robots can aid in health care, and are much more approachable than robots that are less anthropomorphized.	Treating military robots as humans can be damaging to those in the military who become emotionally attached to these robots.

	Robot Entertainment	Robot Companions
Human rights	With artistic endeavors, will the artistic value of humans be downplayed by a robot's ability to do the same, and put out more of it?	With a robot that is designed to be a companion, and is designed to feel and interact with a person in the same way people do, would these robots then be human enough to have rights, more so than just humanoid robots in form?
Government	Will robots have the same level of free speech, etc. as people do? Will they be able to criticize society as an outside observer?	Will the thoughts and capabilities of these robots be restricted by the government? For what reasons might this happen.
Accountability	Media can very easily influence people, and in the case of robot produced media, who is going to ensure that this content is not negatively influencing people?	Will these robots be held accountable for any negative effects on a human's mental health? What happens if a human becomes too attached to the robot or is negatively affected by what the robot says to them? Is this the robot's responsibility?
Safety and Security	Robotic stunt doubles may allow for riskier stunts in the film/TV industry, but does this jeapordize the safety of the people involved.	How will these robot protect personal information? What will these robots due if someone's safety is in danger, for example if a human's life is at risk should the robot call someone for help?
Transparency/ Explainability	Media that is produced by robots should make it clear that this is the case.	The way that the intelligence of these robots is designed should be very clear. People are obviously unpredictable, but the way in which a personality is produced should be very open.
Fairness and Non-discrimination	Any potential bias by designers should be addressed so that the entertainment provided by robotic systems does not perpetuate stereotypes or other scenarios like that.	People may find that the way robots with social capabilities act to be more 'proper' and might expect people to act that way, influencing how we see people that act differently for any number of reasons.

Religion		Robotic companions could be seen very differently depending on how religion adapts to the new technology. If they are seen to have 'souls,' or are able to go to some form of heaven, ect. It is likely that humans will grow to have more empathy toward robots and be more compassionate. On the other hand if they are painted to be empty machinery that only exists to make human life easier than robotic companions might be treated more like toys or equipment.
Identity	If these robots are able to replicate people well enough that they can truly be seen as companions, maybe even romantically, will this change how people see other humans?	Will we treat these robots in the same vein as pets, where relationships with them are distinctly different from our relationships with people?
Human control of technology		These robots are, by design, supposed to have no human control, therefore they must be very stable in order to function consistently without help.
Professional responsibility	When designing machines for entertainment, do those designers have responsibilities to prevent people from indiscriminate virtual reality? Or should they just make it as much as similar to the real world as possible?	It is up to designers to ensure that the personalities these robots exude are as unbiased as possible, since otherwise the bias of those designers spreads.
Promotion of Human Values / Public Interest	This kind of entertainment could excel at changing public interest for the same reasons that personalized advertising has the potential to.	Will these robots promote genuine social interactions and relationships or will people prefer relationships with robots because they are "easier"?
Anthropomorphization	Entertainment produced or portrayed with robots will likely inadvertently cause people to anthropomorphize robots of all kinds more.	Treating a robot companion as a human can add to the functionality, making it easier for humans to make meaningful connections with the robot.

Appendix C - Summary of Ethical Themes

Privacy

In recent years, privacy has become more engaged with the development of robotics. For example, outdoor robots like drones, or surveillance robots, can monitor pedestrians; robots with artificial intelligence can monitor userdata and personalize commercials. These robots can invade human's privacy. Thus protecting privacy is a significant topic when designing robots. When it comes to a robot interacting with humans, we need to think about whether the robot's behavior might potentially violate privacy before applying it to our society. We should have the ability to restrict data processing, and ensure the collected information can be easily erased from the system.

Government

Governments play a crucial role in ensuring human rights, preventing robots from physically hurting humans and other potential issues. The government should establish a sound law and regulate not just robot companies but also individual robot owners. In addition, the domain of military robots is mainly shaped by the interests of governments although this might change if advanced military technologies become available to non-government actors. In order to prevent major conflicts in the future, all governments should endorse an international treaty regarding the control of lethal uses of robots.

Accountability

The accountability of robotics can be divided into three essential stages across the lifecycle of robots: design (pre-deployment), monitoring (during deployment), and redress (after harm has occurred). It can be challenging to decide whether the harm is caused by terrible robot design (robot companies), misuse of robots (users), or both. Creating proper accountability protocols and procedures is an indispensable topic within the development of robotics, as it could efficiently teach people their responsibility.

Fairness and Non-Discrimination

In any case where a robot might directly or indirectly be in contact with humans, it is important that it treats all equally. This may seem like something that would be 'natural' for something that is not programmed to have any inherent predisposition to different groups of people, yet this is not always the case. Functions that a robot relies on, such as facial detection, or algorithms for decision making, can have inherent biases, either intentional or unintentional. These biases may be the result of poor data sets or algorithm training, or just bias on behalf of the programmers of these functions. It is important to catch and correct these errors, so that robots are ensured to be equitable in their interactions with humans.

Identity

Sense of identity is something that can be challenged by robots, particularly when robots are capable of doing more and more 'human' things. Identity can be discussed by either how robotics affects the identity of individuals or groups, as in how they see themselves and how that has changed due to robotics. One such example is the displacement of workers due to automation. If workers' sense of identity is, in some ways, linked to their job, automation might have a negative impact on their identity. On a larger scale, the identity of humans as a whole might eventually be affected with the development of robots.

Anthropomorphization

Anthropomorphization is the application of human-like qualities to something that is not human, such as describing an object as 'breathing' even though it cannot. Robots that interact with humans do things that people do, or traits that people like can often be subjected to anthropomorphization. Giving a robot a name is one such example, as many bomb disposal robots in military use have individual names and are sometimes even given funerals when they are 'retired'. Anthropomorphization may change how people view robots, or how people view other humans. As such, it is important to consider when a robot should be anthropomorphized, and when it shouldn't. This can be dependent on the domains for the robot, such as anthropomorphized for companion robots, and non anthropomorphized for industrial robots.

Human Control of Technology

Human Control of Technology is a significant topic with three main principles: human review of automated decision, ability to opt out of automated decision, and other general issues in human control of technology. Guaranteeing human involvement and human control in automated decision is one of the basic principles in the application of robotics, as it ensures potential ethical issues within human control. When interacting with robots, humans should have the right to review automated decisions, and individuals' choices should not be subject to the robotic system.

Professional Responsibility

In order for progress to be made in any field, leading specialists conduct research in the interest of the general public. It is these professionals' responsibility to guide these investigations with caution and awareness of the implications and effects of the knowledge they pursue. More so, professionals stand as the translators of their findings to the public to explain the uses, possibilities, and dangers of their findings. By conducting research and educating others, leading specialists grow their field and keep an informed public as to how their findings will affect their lives.

Promotion of Human Values/ Public Interest

As advances are made in various fields, the public have influence on the fields they choose to focus on, as the public interest tends to lead the direction of technology development. Social

media has made it easier than ever for individual people to voice and discuss their perspectives on any given topic. Since people can get their own voice out so easily, the public can easily encourage or restrict topics of research. This can be done through events, petitions, protests, and fundraisers. The ultimate goal of technology, or specifically, robotics, should be promoting human values, which can be divided into three principles: human flourishing, access to technology, and leveraged to benefit society.

Safety & Security

With robotic technology becoming further integrated into our lives, people interact with an increasing number of data collecting devices on a daily basis. Despite efforts to make technology secure, every technology faces the risk of cyberattacks. A cyberattack in the form of a data breach can risk the privacy of citizens and often results in identity theft. Robots can also be hacked and this might give the attacker full or partial control of the robot. This can be a risk to safety if the attacker uses the robot to perform harmful acts. For example, if hacked, an autonomous vehicle could crash, a surgical robot could malfunction during surgery, and a military robot could become deadly in an unintended way. It is crucial to have plans for preventing, detecting, and responding to cyber attacks for any technology.

Transparency & Explainability

It is important for companies to maintain the explainability of their technologies and to be transparent with the public. Explainability refers to the ability to provide reasons for how and why a technology works a specific way. This is a critical aspect of holding people or “moral agents” responsible for a technology’s impact on individuals, society, and the planet. Transparency builds on explainability as part of a process of disclosing information about the technology to users. Information about what personal data the technology is collecting on users and how this data is being used should be disclosed. This is crucial for obtaining informed consent and allowing users to evaluate the ethics of a company's practices. Transparency must be balanced with the right to privacy; a company should not disclose information that violates users’ right to privacy.

Appendix D - Survey Questionnaire

In modern society, technology is developing at a fast speed. Among those technologies, robotics is one of the most eye-catching fields, as it brings infinite possibilities to our lives, and its application closely connects with every single aspect of human life. Moreover, with the development of robotics, people will no longer be the only species with intellect, which arouses many ethical discussions and concerns towards robotics. This survey is provided to help us understand how people view robotics and the potential challenges associated with it. By completing the survey, you will learn about robotics and get the chance to think through future challenges or dilemmas in robotics applications. This survey is anonymous and no personally identifying information will be collected. You must be 18 or older to complete the survey. The IRB approval number for this survey is IRB-21-0206. If you have any questions please email djrodriguez@wpi.edu

The following survey will be used by students at Worcester Polytechnic Institute for a study on ethics in the field of robotics.

1. What is the highest degree or level of school you have completed?
    a. No schooling completed
    b. Some high school, no diploma
    c. High school graduate, diploma or the equivalent (for example: GED)
    d. Some college credit, no degree
    e. Trade/technical/vocational training
    f. Bachelor's degree
    g. Master's degree
    h. Doctorate degree
2. Have you ever interacted with or used a robot?
    a. I have been in contact with robots
    b. I have heard about robots from people in real life
    c. I have heard about robots online or from fictional works (ie. movies, books, TV)

    2a. If so, what kind of robots were they?

3. A friend recommends you get the HouseBot 2.0, the new trend taking the world by storm. The robot cleans, cooks, acts as an assistant, everything needed to help improve home life and keep you organized. You also see articles describing how the robot might send your information to companies for targeted advertising. Do you buy the robot?
    a. Yes
    b. No
4. Robots that have human traits will benefit society more than robots that do not.
    a. strongly agree
    b. agree

    c. neutral
    d. disagree
    e. strongly disagree
5. Biomechatronics is using robotic parts in order to improve the function of the human body. They can be used to combat disabilities, for example prosthetics and exosuits, as well as expand upon human senses, like using a brain implant in order for someone who is color blind see color in all spectrums, not only what's visible to humans. Do you think people should be able to augment their bodies as they see fit?
    a. strongly agree
    b. agree
    c. neutral
    d. disagree
    e. strongly disagree
6. Do you think robots will be able to fully replace teachers and/or doctors?
    a. Agree
    b. Robots can fully replace teachers but not doctors
    c. Robots can fully replace doctors but not teachers
    d. Robots can assist teachers or doctors but can never fully replace them
    e. Disagree
7. Do you think humans have emotional connections with robots?
    a. Yes
    b. Depends on both appearance and utility of the robots
    c. Depends on the appearance of the robots (human-like or animal-like)
    d. Depends on the utility of the robots (interact with human or not)
    e. No
8. Do you think the potential benefits of robotics outweigh the potential risks?
    a. strongly agree
    b. agree
    c. neutral
    d. disagree
    e. strongly disagree
9. I am afraid of robots tracking my data or invading my privacy.
    a. strongly agree
    b. agree
    c. neutral
    d. disagree
    e. strongly disagree
10. I fear that robots will eventually become more intelligent than humans in a way that is harmful to society.
    a. strongly agree

b. agree
c. neutral
d. disagree
e. strongly disagree

11. I worry that robots could be hacked and become a threat to our national and personal security.
    a. strongly agree
    b. agree
    c. neutral
    d. disagree
    e. strongly disagree
12. Rank the following in order of what concerns you the most to what concerns you the least about robotics:
    a. Privacy (data collection)
    b. Security (cyberattacks)
    c. Robots surpassing human intelligence & undermining human values
    d. The use of robots by governments and militaries
    e. Robots taking jobs
    f. other _____

13. (Open Ended) Of the non-fictional robotics technologies that you have heard about or seen, which do you think are the most problematic, and why?

14. (Open Ended) Of fictional robotics technologies that you have heard about or seen, which scare you the most, and why?

15. (Open Ended) Do you have specific concerns related to robots? What are they?

Appendix E - IRB Approval Letter

Institutional Review Board

FWA #00015024 - HHS #00007374

Notification of IRB Approval

Date: 09-Dec-2020

PI: Gong, Yaru

Protocol Number: IRB-21-0206

Protocol Title: Applied Robot Ethics Lab Survey

Approved Study Personnel: Gong, Yaru~Rodriguez, David~Fichtner, Kaitlyn~Desousa, Brian~Telliel, Yunus~Calli, Berk~

Effective Date: 09-Dec-2020

Exemption Category: 2

Sponsor*:

The WPI Institutional Review Board (IRB) has reviewed the materials submitted with regard to the above-mentioned protocol.We have determined that this research is exempt from further IRB review under 45 CFR § 46.104 (d). For a detailed description of the categories of exempt research, please refer to the IRB website.

The study is approved indefinitely unless terminated sooner (in writing) by yourself or the WPI IRB. Amendments or changes to the research that might alter this specific approval must be submitted to the WPI IRB for review and may require a full IRB application in order for the research to continue. You are also required to report any adverse events with regard to your study subjects or their data.

Changes to the research which might affect its exempt status must be submitted to the WPI IRB for review and approval before such changes are put into practice. A full IRB application may be required in order for the research to continue.

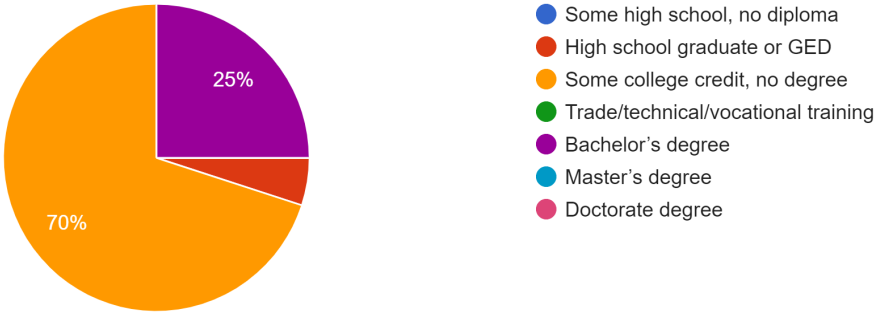
Please contact the IRB at irb@wpi.edu if you have any questions.
*if blank, the IRB has not reviewed any funding proposal for this protocol

Appendix F - Survey Results

Below is the distribution of responses for the multiple choice survey questions. Open-ended responses have been omitted to protect the privacy of survey participants.

What is the highest degree or level of school you have completed?

20 responses

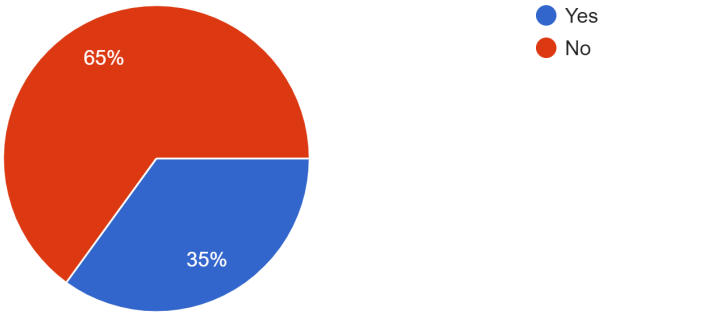


Have you ever interacted with or used a robot?

20 responses

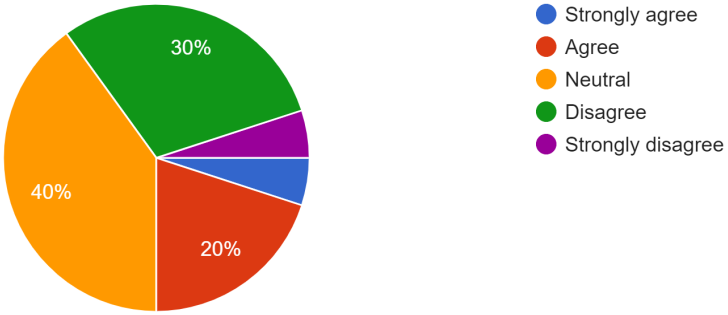
A friend recommends you get the HouseBot 2.0, the new trend taking the world by storm. The robot cleans, cooks, acts as an assistant, everythi...ies for targeted advertising. Do you buy the robot?

20 responses



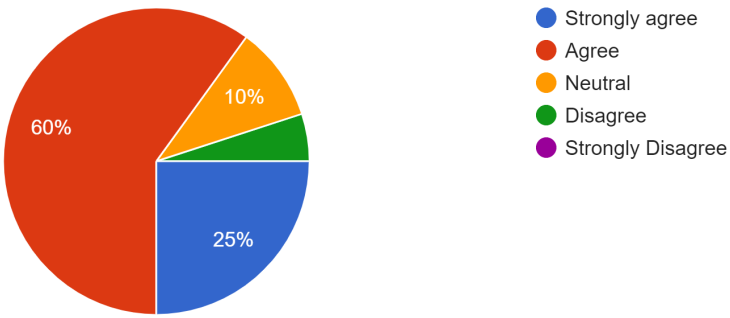
Robots that have human traits will benefit society more than robots that do not.

20 responses



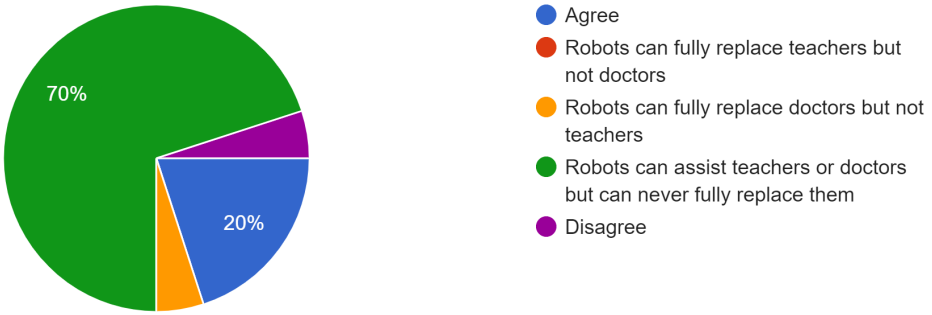
Biomechatronics is using robotic parts in order to improve the function of the human body. They can be used to combat disabilities, for example pro...d be able to augment their bodies as they see fit?

20 responses



Do you think robots will be able to fully replace teachers and/or doctors?

20 responses

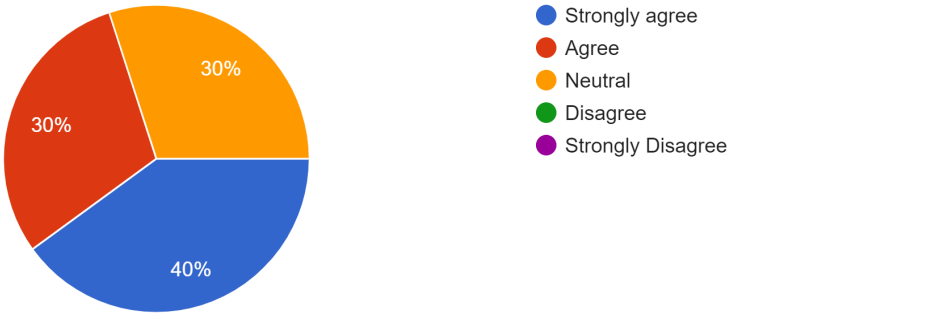


Do you think humans have emotional connections with robots?

20 responses

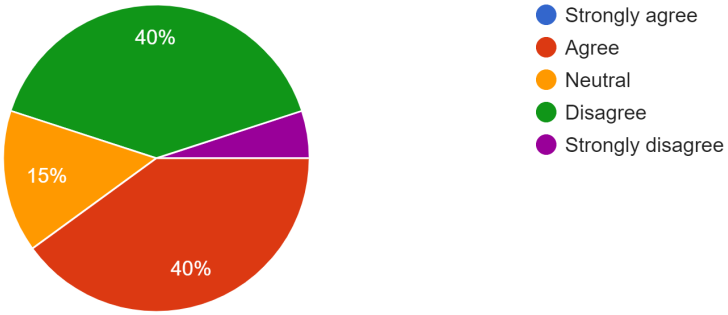
Do you think the potential benefits of robotics outweigh the potential risks?

20 responses



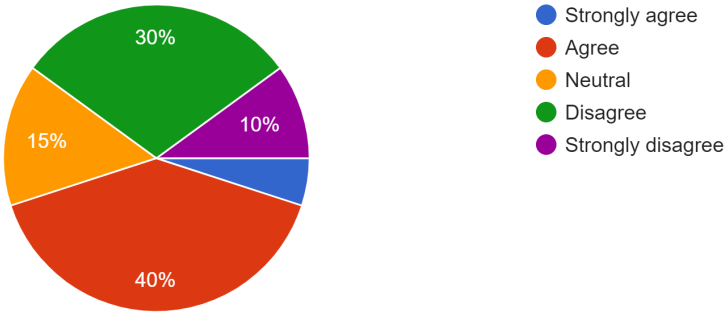
I am afraid of robots tracking my data or invading my privacy.

20 responses



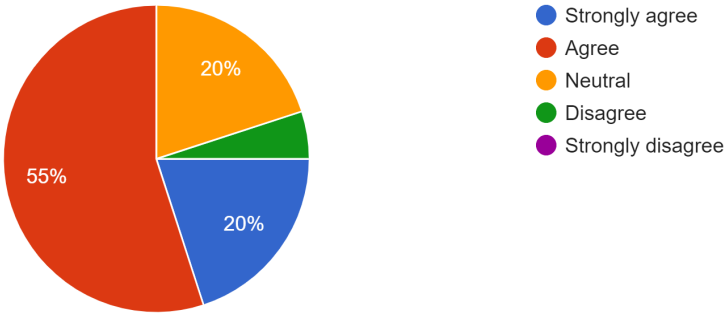
I fear that robots will eventually become more intelligent than humans in a way that is harmful to society.

20 responses



I worry that robots could be hacked and become a threat to our national and personal security.

20 responses



Appendix G - Domain Web Pages

Companion Robotics

Story

Year 2035:

Due to the pressure of the aging society in Japan, companion robots became a popular trend, especially in elder care. Kazuki is a 70-year-old man who lives by himself. His children are worried about him since they live in different cities. To better take care of Kazuki, his children decide to buy a companion robot. This senior care robot's job mainly is to take care of older people, and if an emergency happens, it will report to the families and doctors. Also, communicating with companion robots might be able to decrease the risk of depression and dementia since it can help the care recipients to relax and maintain a good mood.

However, Kazuki is not that happy with this change. His children visit him less after having this robot as they assume that it will fulfill their father's every necessary need, including emotional and physical support. Furthermore, Kazuki feels an absence of privacy as the humanoid robot monitors him 24-7 even when he goes to the bathroom or takes a shower. Kazuki also feels he is monitored and imprisoned. For instance, the robot is programmed to peer around Kazuki, and his children can view his location as the robot updates his location by real-time streaming service. His children can even interfere with Kazuki's life by ordering the robot to encourage and guide him back to the designated area.

Moreover, Kazuki is not comfortable communicating with the robot because he does not feel any sincerity behind the robot's words, especially when it uses emotional expressions. The first reason is that he feels embarrassed talking to a machine, especially in front of other people. Kazuki complains to his children, 'Only kids talk and make friends with a doll.' Another reason is that he is aware that robots only mimic human behaviors and do not resonate with the meaning behind the words. Kazuki doubts that the companion robots positively affect care recipients' mental health, as the commercial said. Because of the reduced visit from Kazuki's family and superficial communications provided by the companion robot, Kazuki feels more lonely than he did before he had this robot.

What are Companion Robots?

A Companion Robot is a robot designed to provide companionship towards human beings, especially patients, children, or seniors. The formats of the companion robots are not all the same. Some look cute and imitate animals' appearances with fur, which can provide more emotional support. The care recipients can interact with them by touching them and talking to them. Some can only understand simple orders and connect with hospitals for healthcare services. Currently, the elder care robot is a companion robot that is primarily used in care homes, and, as such, it is seen as a solution to the needs of an aging society. However, there are uncertainties that to what extent companion robots can replace human caregivers with the consideration of potential harms.

Discussion Questions

Click the + on the right of a question to view related perspectives and potential starting points for considering these ethical concerns.

What are some social issues behind substituting a robot for human care or companionship?[4, 8]

- "This population problem is already very real in countries like Japan, where there will be an estimated shortage of 1 million caregivers by 2025. The U.S. is facing a similar dilemma — as the percentage of people aged 65 or older is expected to rise to roughly 26% by 2050."[4]

Can companion robots be physically and psychologically beneficial to care recipients in ways that are more effective than human caregivers?[1, 3]

- " Content analysis identified 3 key benefits of and 3 barriers to the use of PARO. Main benefits include: reducing negative emotion and behavioral symptoms, improving social engagement, and promoting positive mood and quality of care experience. Key barriers are: cost and workload, infection concerns, and stigma and ethical issues."[1]

How well are Companion Robots accepted by elderly people?[5]

- "The acceptance of care robots has so far been rather poor, despite the potential benefits they are meant to provide."[5]

When receiving care from companion robots, would care recipients receive less care from humans? Would care recipients face psychological effects from interacting more with humanoid robots than humans?[2, 5]

- "The worry is that the use of robots in elder care for tasks such as lifting, carrying, or even cleaning, might result in a reduction in the amount of human social contact that an elderly person experiences."[2]

How will the Companion Robot affect human rights, especially privacy?[2]

- "Our second concern is that there is a risk that monitoring could infringe on the right to privacy. The privacy of people in general should be respected"[2]

Will people feel embarrassed and uncomfortable when interacting with companion robots, since they are talking to a machine? How could we prevent it?[1, 6]

- "Some cases described individuals as appearing embarrassed about interacting with PARO especially in front of others, and this might have influenced their reactions."[1]

Would people feel they lose control since their life is getting 'arranged' by care robots? Will people feel they lose their dignity and independence? Which one is better compared to taken care of by human caregivers?

- "Such robots could make elderly people feel that they had even less control over their lives than when they are dependent on human nursing care."[2]

Is it deception to have emotional connections with companion robots? Can companion robots give true caring if emotional connections are based on deceptions?[2, 6]

- "For an individual to benefit significantly from ownership of a robot pet they must systematically delude themselves regarding the real nature of their relation with the animal."[2]

Who should control Companion Robots? Doctors, families, or users?[2]

- "Robot technology that was under the control of an elderly person could empower them and increase their independence."[2]

Themes

Learn more

Resources

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Humanoid Robotics

Story

Year 2045:

Jennifer has a daughter who is seven years old. Jennifer is busy at work, and she can not spare much time for her daughter. Jennifer's friend Ashley recently bought a humanoid robot to take care of her child. This robot is designed by a company that targets parents who can not look after their children during the daytime. Lots of parents chose to buy humanoid robots to take care of their children instead.

After one month, Ashley was so satisfied with the humanoid's overall performance on child care service that she suggested Jennifer purchase the same robot, so that she does not have to be concerned about her daughter's well-being while she is at work. Based on Ashley's shared experience, the robot performs outstanding communication skills and provides excellent entertainment services while caring for her child. She further emphasized that the childcare robot has identical features and external appearance to a human, which helped her child better communicate with the humanoid robot.

Nonetheless, Jennifer has her own thoughts. On one hand, she needs someone to help her take care of her daughter, and it seems like the robot's companionship could be beneficial for both the physical and mental health of her child. On the other hand, Jennifer has a lot of worries about those human-looking machines. In the end, she still decides to bring it home.

At first, Jennifer has difficulty introducing the robot to her daughter because she does not know whether she should introduce the robot as a friend or a machine. A robot's human-like appearance sometimes can be confusing, especially to a child whose cognition is still developing. Once Jennifer's daughter was crying at home about arguments with friends at school. The robot was not able to show feelings or compassion, instead it just said some common phrases pre-programmed to comfort kids. However, after hearing those words, Jennifer's daughter became more upset because she felt that the robot did not understand her situation. After a few months, Jennifer found that her daughter was always giving other people orders because she got used to talking to robots, which influenced her social skills. Her friends at school stopped hanging out with her because of her authoritative behavior. Then, she started to imitate the robot's behavior, from speaking to facial expression, making Jennifer worried. Jennifer's daughter learned to hide her emotion and became not as expressive as other kids her age. Jennifer thinks this humanoid robot is gradually undermining her daughter's mental health. In the future, if her daughter has some emotional disorder such as alienation, depression, etc, who should take full responsibility for that?

What are Humanoid Robots?

A Humanoid Robot is a robot whose body shape and face resemble the human appearance. Most humanoid robots can interact with humans. Building a robot that looks like a human has generated heated discussions on moral and ethical issues, as humanoid robots' appearance is controversial. This unique feature can make it easier for humans to build emotional connections compared to other robot types. The professional responsibility in this field is to think about the necessity and applications of anthropomorphization with the potential risks of co-existing with robots. Preventing discrimination between the human species and humanoid robots can also be a challenge we need to think about.

Discussion Questions

Click the + on the right of a question to view related perspectives and potential starting points for considering these ethical concerns.

Can people accept the external appearance of a humanoid robot? How will robot's human traits influence the way people treat them?[1, 2]

- "When things go wrong with robots in Sci-Fi, they almost always take human form. Beyond the "robots out of control" trope, there's the psychological factors that come to play as we can't decide how to treat them, or how they should treat us."[1]

What do the children's social and moral relationships with a humanoid robot look like? How do children perceive humanoid robots?[3]

- "The interview data showed that the majority of children believed that Robovie had mental states (e.g., was intelligent and had feelings) and was a social being (e.g., could be a friend, offer comfort, and be trusted with secrets)."[3]

Should we introduce humanoid robots to young children? If so, would it affect the child's interaction with other people based on their lack of ability to differentiate between humanoids and human beings? How can machines affect children's behavior and interaction based on their age and cognition level?

- "In terms of Robovie's moral standing, children believed that Robovie deserved fair treatment and should not be harmed psychologically but did not believe that Robovie was entitled to its own liberty (Robovie could be bought and sold) or civil rights (in terms of voting rights and deserving compensation for work performed)."[3]

Since the humanoid robots only work for profit, will their involvement undermine society's trust?[4]

- "Cooperation is a key feature of our species, essential for social life. And trust and generosity are crucial in differentiating successful groups from unsuccessful ones. If everyone pitches in and sacrifices in order to help the group, everyone should benefit. When this behavior breaks down, however, the very notion of a public good disappears, and everyone suffers. The fact that AI might meaningfully reduce our ability to work together is extremely concerning."[4]

Should we program humanoid robots to have emotion? If so, would they deserve to be treated humanely? Should they possess rights and accountabilities?[5]

- "If we did want to build a robot with real sensations, how should we proceed? When I ask my students this question, they often respond with "Why would anyone want to do that?" That's a good question that reflects an understanding that robots, as we usually think of them, don't feel anything, and so can't suffer. That's why we think they're ideal for jobs that would be dangerous to people, like fixing damaged nuclear facilities."[5]

How could humanoid robots make some humans believe that they do have feelings even if it is not true? What can be the potential impact that some people believe humanoid robots have feelings when they actually do not?

- "The results revealed that the developed robot has a positive effect on the teacher's impression about reliability and sympathy."[6]

Can humanoid robots be moral without sensations? If not, how can people stay in control of the fast-developing complex artificial intelligence? How can people protect themselves against unintended consequences caused by humanoid robots? Who should take the responsibility if it happens?

- "The conceptions of morality and creativity interplay with linguistic human beings instead of non-linguistic humanoid robots, as humanoid robots are indeed docile automata that cannot be responsible for their actions."[7]

Do people hold a humanoid robot morally accountable for the harm it causes? Who should take more responsibility if the humanoid robots cause harm?[8]

- "Sixty-five percent of the participants attributed some level of moral accountability to Robovie. Statistically, participants held Robovie less accountable than they would a human, but more accountable than they would a vending machine."[8]

What considerations do we need to make when maintaining a society where humans coexist with humanoid robots? Should humanoid robots be fairly treated like humans?[9]

- "Do robots have moral and legal rights – the right not to be tortured, the right to consent to sex (can you consent to your own programming)? As Jinks points out, if robots are indistinguishable from humans but have restrictions placed upon their behaviour and movement, "aren't we legislating discrimination?""[9]

Themes

Learn more

Resources

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Distributed Robotic System

Story

Year 2050:

On a winter morning, Tim wakes up to the smell of toast cooking in his *LifeBot* smart toaster. His *LifeBot* virtual AI assistant, Charlie, greets him: "Good Morning Tim! Today it is 35 degrees and cloudy. You have a meeting at 9am and there are currently seven parking spaces available outside your office building." Tim drags himself out of bed and gets ready for work.

LifeBot is a massive tech company which rapidly gained popularity over the last 3 years for its vast line of connected IoT devices that can perform a multitude of everyday tasks. *LifeBot* has three major product lines for businesses, households, and smart cities. Tim lives in a *LifeBot* operated smart city and smart home. He loves how well his home devices integrate with the smart city.

Running late for his meeting, Tim rushes out to his self-driving car to head for work. The car is already running and has picked its destination for the closest available parking spot to the entrance of Tim's work building. The car takes him on a different route to work today and he assumes it must be avoiding an accident or other traffic along the normal route. When Tim gets to the office, no one is at their desks. He goes to the break room and finds everyone watching the news and frantically checking their phones. "What's going on?" he asks his co-worker. She replies, "*LifeBot* had a data breach this morning. I heard it only affected the business management devices but this could mean that our personal data was breached as well. Either way, we can't do much work today until it all gets sorted out." Realizing how much personal data *LifeBot* technology has collected on him, Tim's stomach drops.

What are Distributed Robotic Systems?

Distributed robotic systems are systems of robots linked through a network, such as the web, for data sharing and cooperative learning and working [4]. Distributed robotic systems can be multi-robot systems in which self-organizing robot teams work in coordination to perform specific tasks [4]. These systems can also include networked intelligence systems such as the smart city described in the story above. Smart cities can have a mixture of networked devices such as weather monitoring systems and robotic systems such as robotic police officers. With robots becoming increasingly advanced, smart cities will likely integrate more robotic technologies in the future.

Distributed robotic systems are becoming further integrated into society as the market for Internet of Things technology, such as Amazon's Alexa or Google Home, grows and Web speeds improve [4]. This is a popular field of research because there are many benefits to using a system of many robots working together. Multi-robot systems are more adaptable because they are not designed for one specific task. They are also more reliable because if one robot becomes damaged, the rest of the system remains intact. They are also very useful for large scale applications because they have a wider field of view. While an individual robot can only gather information from its immediate surroundings, robots that are part of a system can access information from its own surroundings as well as the surroundings of other robots in the system. An example of this is military microdrones which communicate with each other on intelligence gathering missions.

Discussion Questions

Click the + on the right of a question to view related perspectives and potential starting points for considering these ethical concerns.

Is Tim aware of what data LifeBot is collecting about him?

- "Notice and consent—considered the cornerstone of data and privacy protection—are significantly weakened within smart city technologies and in data/urban science becoming an empty exercise or being entirely absent. Individuals interact with a number of smart city technologies on a daily basis, each of which is generating data about them."[2]

Is any personally identifiable information being collected on Tim? How is anonymity maintained? [2]

- "One of the key strategies for ensuring individual privacy is anonymization, either through the use of pseudonyms, aggregation or other strategies. The generation of big data and new computational techniques, however, can make the re-identification of data relatively straightforward in many cases" [2]

Could LifeBot be selling Tim's data for purposes such as custom advertising and has Tim consented to the use of his data in this way? [5]

- "By loading the banner ad, a cookie is placed on the web user's computer. In this way, online advertising companies are also able to track (part of) a user's movements on the web." [5]

How does custom advertising limit free choice or shape the culture and values of society?

Could the government get access to data collected from LifeBot technologies? Could mass surveillance of the people by the government be a threat to democracy or civil liberties? [1]

- "On the other hand, human rights organizations are legitimately concerned about mass surveillance as a threat to civil liberties. A corrupt government can get to know your every move, habit, medical problem, and other private detail."[1]

What laws should there be to protect Tim's privacy and rights?

How do smart technologies in cities and homes improve the quality of life for the citizens currently and how will they in the future? To what extent is it worth sacrificing personal data privacy for convenience? [3]

- "People who live in smart cities or who are visiting smart cities have the immediate benefit of being connected to the governing body for information and services. The quality of their lives can be improved with better traffic management, waste removal, snow removal, and more." [3]

How could a data breach or cyber attack impact the people? How secure is the data being collected? [1, 4]

- "for instance, the increasing dependability of primary services from complex systems, and the unpredictability of robot team behavior."[4]
- "Some government systems are simply corrupt to the point they cannot guarantee decent protection of their citizens' personal data."[1]

How does mass data collection lead to deindividualization when people are constantly grouped into categories based on their data? [5]

- "When group profiles are used as a basis for decision-making and formulating policies, or if profiles somehow become public knowledge, the individuality of people is threatened. People will be judged and treated as group members rather than individuals." [5]

Smart cities are beginning to integrate roboticized police forces. What human biases are present in roboticized policing, considering that the machine learning algorithms used for profiling were trained using data from an already biased law enforcement system? [1]

- "In 2016, a coalition of US civil rights organizations picked predictive policing apart with a joint statement describing the technology as "biased against communities of color."[1]

Themes

Learn more

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Surgical Robotics

Story

Year 2075:

Sarah has been noticing pain in her chest the past couple weeks and it has been getting more severe the last few days. She finally decides to go see a doctor and her doctor tells her that she has plaque in her arteries and is at high risk for a stroke. She will need a coronary artery bypass as soon as possible. The doctor informs her about a surgical robot at his hospital that is capable of completing a coronary artery bypass entirely by itself, without the need for a human surgeon. He says the robot is worth $2 million and is actually more precise than humans.

Sarah is very nervous about the procedure because she has a rare pre-existing condition that puts her at higher risk for complications and she is unsure if she is willing to trust a robot to do the procedure. She brings up her concerns with the doctor and he assures her that the robot has successfully completed the operation many times. He also tells her that if she wants the procedure to be done by a human surgeon she will have to wait at least 2 months. The hospital has been hiring less human surgeons now that robots can do many of the common surgical procedures. Consequently, their schedules fill up far in advance and prioritize operations that cannot be done by surgical robots.

Since Sarah does not want to wait to get the operation done and her doctor has convinced her that robotic surgery is actually more safe than human surgery, she agrees to schedule the surgery with a robot. She calls the hospital's Financial and Billing Assistance Center to make sure her insurance will cover the cost of the procedure. She is put on hold for about 30 minutes then a woman picks up the phone and says "Unfortunately robotic surgery is not covered by public insurance policies". Sarah had been diligently saving money for the last couple years so she could afford the out of pocket cost if absolutely necessary, but it does not seem right that such a common and vitally important operation would not be covered by insurance. She decides to call other hospitals to explore her options.

What are Surgical Robots?

Surgical robots are becoming increasingly advanced and common in the healthcare industry. These robotic systems can be controlled by surgeons' direct actions, automatic and programmed before the operation, or semi-automatic constraining the surgeons movements [6]. Surgical robotics is especially useful for minimally invasive procedures where it can reduce patient recovery time and possibly increase accuracy and precision [7]. Surgical robots can also be helpful for neurological procedures that require very fine, delicate movements that are difficult for surgeons to perform without robotic assistance [7].

Discussion Questions

Click the + on the right of a question to view related perspectives and potential starting points for considering these ethical concerns.

Does Sarah fully understand the risks involved with robotic surgery? Has Sarah discussed the risks enough with her doctor to be able to give informed consent? [1,6,9]

- "Family verbal or written informed consent should be obtained, with patient assent if appropriate, with emphasis on the innovative nature of the device or procedure" [1]
- "Patients present with a wide variety of educational and cultural backgrounds, which should be considered during the informed consent discussion. Perhaps due to the aggressive marketing of robotic surgery or patients' desire for the latest technology, patients generally seem enamored with robotic surgery."[1]

Why might the doctor be motivated to recommend robotic surgery over human surgery? [5,6]

- "Hospital staff may try to persuade patients to accept the robotic procedure in order to pay off the costs of buying and installing the system" [5]

Has the hospital unnecessarily spent money on expensive surgical robots to appear more "innovative" when human surgeons may be a safer and less expensive option? [1,3,6]

- "But a common optimism bias among surgeons and institutions creates a tendency to overestimate the positive effects of the new." [6]

What would people who cannot afford robotic surgery do when there are no human surgeons available? [3]

- "As the cost of new technologies is expected to be high and in various health care systems may not be covered or only partially covered by the public insurance, many patients may not be able to afford robotic treatment and the benefits of the new technology" [3]

Does the robot have experience operating on people with Sarah's pre-existing condition? How might a lack of training data for pre-existing conditions and minority groups create unintended bias in robotic surgery? [5]

- "A robot might, for example, be subtly slower or a bit less precise given situations that were rare in its training set, and the effects of these small differences may be hard to detect on a case-by-case basis, while still contributing to biased outcomes when analyzed at the population/subpopulation level" [5]

Will less human surgeons be entering the medical field when so many jobs are being taken over by surgical robots? [8,9]

- "who cares if the surgeon is denied a chance to become excellent at surgery if the machine that replaced her provided a better outcome?" [9]
- " if the systems became more autonomous and allowed the surgeon to become deskilled, then professionalism and excellence would be diminished and with it the ethical value of the work done" [9]

Who would be held accountable if there were complications in Sarah's surgery— the hospital, the robot company, the doctor, the technician? [3,4,8]

- "As in surgical practice, the grounds for liability with robotic surgery include damage to patients, causality, illegality and guilt. Nevertheless, litigation with the use of robotic surgery may be complex." [3]

Will people begin to lose trust in the healthcare industry if surgical robots are unreliable? [6,8,9]

- " surgical innovation can potentially cause increased mortality and morbidity compared to standard techniques. Surgery in itself is not benign and there are risks from infection, anesthesia and longer hospital stays. But there are also possible financial and psychological harms as well as loss of trust in the 4 medical professions." [6]

How will Sarah's information and privacy be protected after the robot has access to all of her medical records? [8]

- "Robotics research and use of robots in healthcare raise questions about which data are collected, how they are stored, who has access to them, who owns them, what happens to them, and so on."[8]

Themes

Learn more

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Domestic Robotics

Story

Year 2070:

For the past three years Marissa's family has been the proud owners of a HouseMaster+ robot, Billy . This household robot won't only clean your house but also orders groceries, cooks, and does your scheduling, everything to help make your home life smooth and relaxing. Billy made Marissa's homelife much smoother, helping to prepare meals, taking care of the kids, and even suggested the best Christmas presents; he became part of the family.

The big story on the news today is that the company that produces the HouseMaster series robots, BetterLyfe, has been storing all the information the HouseMaster robots have been collecting in order to better market items and services from other BetterLyfe franchises to the robots' owners.

The public seems to have two reactions: outrage at that the company collected and used the customers private information for monetary gain, or others believe that as long as the information wasn't distributed to other companies and organizations the breach of privacy was somewhat minor. Seeing this unfold Marrisa's family doesn't know how to react, but they don't like the idea of being monitored. For now they shut down Billy until they make a decision. Her 2 year old, having spent most of their life playing and bonding with Billy, cries as the robot is placed in the garage lifeless.

The coming week is filled with unforeseen obstacles for Marissa's family. Marissa herself is noticing how little time there is in the day having to cook, clean, and keep track of everything alone. She is only barely able to finish the kid's lunches before school the first few days, and is late to a meeting because she lost track of time cleaning the house. Needless to say it seems Marissa and her family have grown dependent on Billy over the last few years. The family now goes forward trying to decide if they will continue to use Billy, or shop around for other similar domestic robots on the market.

What are Domestic Robots?

Domestic, or household, robots are autonomous robots used to make homelife run smoother by completing chores and other mundane tasks. Current domestic robots, like Roombas, are specialized to complete a specific task and are confined by factors like movement, size, and the current complexity of automated technology. As the field develops we will likely start to see more domestic robots like Honda's Asimo robot, a humanoid generalized robot that can interact with owners as well as complete almost any household chore.

Discussion Questions

Click the + on the right of a question to view related perspectives and potential starting points for considering these ethical concerns.

What are the moral implications of the privacy breach committed by BetterLyfe? [1, 6]

- "The need for such considerations is clear: future robots in the home could introduce new or amplify existing security and privacy risks for homeowners and other occupants. In many cases it may not be obvious how to overcome these security and privacy risks." [1]
- "We may not know much about how domestic robots of the future will be designed, but one thing is certain: security, safety, and privacy will not be thrown in as afterthoughts." [6]

Will people form emotional connections with domestic robots like Marrisa's youngest child? [5, 8]

- "The acceptability of robotic devices in home settings... does not depend only on the practical benefits they can provide, but on complex relationships between the cognitive, affective and emotional components of people's images of robots" [5]
- "We propose that users will perceive domestic robots as a new kind of entity." [8]

What will happen as humans become increasingly reliant on robots to do what we consider to be easy and essential tasks?

- "Many Americans are not equipped to earn their living in a future society where all the routine tasks are automated. That's going to be a big, big problem. But it is ultimately solvable by raising our educational standards." [14]

How will our privacy be affected as domestic robots become more complex? [4]

- "The idea of a smart watch that lets you keep an eye on your children might sound like something a security-conscious parent would like: a smart watch that can be hacked to track children, listen in on their surroundings, and even fool them into thinking a call is coming from their parents is the stuff of nightmares." [4]

If a domestic robot like Billy were to malfunction and injure someone, who would be held responsible? [13]

- "Such claims may arise from tort law or from special laws like road traffic acts, product liability regulation, or anti-discrimination laws, if the AI application derives discriminatory consequences from the data it uses. In addition, liability can of course also be the result of the contractual relations between the injured party and one of the other parties involved." [13]

Should domestic robots ever be allowed to care for children unsupervised or otherwise? [11, 12]

- "Robot-Assisted Therapy (RAT) has successfully been used to improve social skills in children with autism spectrum disorders (ASD) through remote control of the robot in so-called Wizard of Oz (WoZ) paradigms." [11]
- "...it has become increasingly apparent that social and interactive skills are necessary requirements in many application areas and contexts where robots need to interact and collaborate with other robots or humans." [12]

How will domestic robots change how we interact with and control technology? [8]

- "The TPB model points to the importance of perceived behavioral control in forming opinions about technology such as users believing they can control when and how technology operates, how adopting such a technology affect their social status, and all other factors of concern. TAM narrows these criteria and places emphasis on the perceived ease of use." [8]

Themes

Learn more

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Biomechatronics

Story

Year 2025:

Jacob's best friend Noah is an amputee that lost his left arm in an accident. Noah was having a hard time adjusting to normal life without his arm and basic prosthetics didn't have enough control for him to comfortably complete everyday tasks like driving and cooking. In an effort to help eliminate his disability and be able to function like he did before the accident Noah got a biomechatronic left arm surgically implanted. The implant responds to his thoughts as if it were the arm he was born with, but comes with the added benefits of being stronger and having different attachments and tools, such as a peeler and knife to help with cooking, various tools like screwdrivers and wrenches, it even replaces his cell phone allowing him to send messages and take calls. In addition to this the arm keeps track of Noah's health and notifies him when to see a doctor. Noah and Jacob now joke about how Noah has become a real life cyborg.

Out of curiosity of his friends' new arm, Jacob decides to do some research on biomechatronics to learn more about the field. In his research he finds there are many different types of biomechatronics, but they serve two main purposes, to eliminate disability and to improve functions of the human body. He had no idea that people without a medical need for biomechatronics could still get implants. At first he's taken aback, why would people put robotic parts into their body if they don't need it, but then he remembered all of the features of Noah's new arm. It did much more than his arm ever could. And so he started looking at biomechatronics that might interest him.

Fast Forward 10 Years

The year is 2035, Jacob and Noah are getting lunch at a diner. Once they finished their meals and paid they made their way to the exit. Before Noah can reach for the door Jason holds out his arm as his hand extends forward from the wrist revealing his newest addition to his body's biomechatronics.

"Another one? How many do you need to get before you're not human?" Noah asks concerned. Ever since Noah got his new arm Jacob has been getting more biomechatronics. Jacob now has an implant that indicates true north, a visual implant to refine his sight, and a RFID chip. None are visible, but Noah worries his friend will never be satisfied with the implants he gets and will always want more.

Jacob is aware of Noah's concern, but he doesn't see a problem, what's wrong with improving one's senses and functions to live a better life. Isn't that what the technology was created for? He replies to Noah nonselauntly walking out the diner door, "If being a cyborg is wrong, I don't want to be right."

What is Biomechatronics?

Biomechatronics is the integration of mechanical and electrical technology with biological organisms in an effort to improve and/or expand biological functions. The growing field currently has two main objectives: to use robotics in order to eliminate a disability and to expand the capabilities of the human body. Biomechatronics designed to eliminate disabilities include devices to help people who are paralysed or have cerebral palsy be able to move around, as well as high grade prosthetics. On the other hand biomechatronics have been developed that allow people to see in multiple spectrums, detect atmospheric pressure, and even gauge radiation levels.

Discussion Questions

Click the + on the right of a question to view related perspectives and potential starting points for considering these ethical concerns.

Will the government have to regulate biomechatronics like the FDA regulates food and drugs? [4, 15]

- "In 2016 together with electronic civil rights and civil liberties researcher and activist Rich MacKinnon, a list of Cyborg Civil Rights were proposed at SXSW. The rights exposed the redefinition and defence of cyborg civil liberties and the sanctity of cyborg bodies. It also foresaw a battle for the ownership, licensing, and control of augmented, alternative, and synthetic anatomies; the communication, data and telemetry produced by them; and the very definition of what it means to be human." [4]
- "Next week," Herr said, "I'm going to present to the Centers for Medicare & Medicaid Services, and I'm going to try to convince CMS to grant the appropriate code language and pricing so that this technology can be made available to the patients who need it." [15]

Should Noah's new arm be covered by insurance?

- "The BiOM is one of the costlier prosthetics on the market – until January of this year insurance companies reimbursed physicians anywhere from $50,000 to $150,000 for the devices, according to BiOM. Although the device is covered by the U.S. Defense Dept., the Veterans Affairs Dept., and various private worker's compensation plans, the device remains in reimbursement limbo at the Centers for Medicare & Medicaid Services (CMS)." [15]

Is there such a thing as going 'too far' with a biomechatronic implant? [22]

- "I feel like a lot of robotics is developing systems because we can, not because we should. With the biomechatronics, it's a great application because we are satisfying that interest and that need to build these systems, but it's definitely for a good purpose, to end disability." [22]

As more people get biomecatronic implants could a new form of discrimination appear? [24]

- "After a long battle with the UK authorities, Harbisson's passport now carries a photo of him wearing his eyeborg, making him the world's first government-recognised cyborg." [24]

How will Noah having biomechatronics affect his opportunities? For example, will he be allowed to play competitive sports?

- "Herr is in no doubt that this is where the technology is heading and his ambitions for it are huge. He says: "I envisage a world in which the technology is so advanced and the human/machine interaction so profound that we can rid the world of disability... and that's the goal: an end to disability." [10]

Would having many biomechatronic implants make Jacob a different type of human or even another species? [10, 18, 23]

- "All of these advances derive, claims Herr, from a concentrated effort to understand the human body better and to emulate it. He says: "Building a bionic limb that has the profound versatility of the human limb is incredibly hard. Right now when you open up your closet, you see lots of shoes. When I open up my closet, I see lots of legs. I have a leg for running, I have a leg for climbing – I have about eight pairs. It's a challenge to build all that capability into a single limb. The human leg is so adaptable and versatile." [10]
- "Pau Prats is a cyborg-artist from Barcelona, and he can perceive ultraviolet radiation. What initially began as basic research for his final year of high school, has become an artistic journey into the frontiers of future human evolution. The 18 year old Catalan is a member of Transpecies Society, an interdisciplinary collective and social project that explores new senses and organs while advocating for non-human identities. It is through their guidance that Prats became a cyborg." [18]

How will biomechatronics change how we interact with technology? [3, 8]

- "Unfortunately, technological progress means my chip is already relatively behind the current technology and it will take a surgical procedure to upgrade it, albeit minor." [3]
- "UA medical student Ben Conner is part of a team that studies the use of robotic exoskeletons. Kids with the disorder wear a wireless control system around their waists and the exoskeleton works with muscles in the legs to propel the body forward and create a more normal walking pattern." [8]

Should biomechatronics be something that everyone learns about? [17]

- "Biomechatronics offers many opportunities for our students at Markham Woods that will appeal to many of our families. Because Biomechatronics combines biology, mechanics, and electronics, it gives us a way to provide students with skills and knowledge that can be used many different ways." [17]

Themes

Learn more

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Military Robotics

Story

Year 2040:

Darius works as a government researcher in Maryland, specializing in military robotics. While Darius used to have more control over what research he was able to conduct, his higher ups have been consistently pushing him more towards looking into robotic solutions that might be used in battle. While Darius is made uncomfortable by the idea, it would be very difficult for him to find another job at the moment, and he thinks that he may be able to either dissuade his superiors from pushing him in this direction, or be able to come up with some potential solutions.

Understanding that Darius is concerned about the direction of his work, one of his higher ups attempts to help convince him that this work is not inherently bad: "Automation could even help prevent loss of life, a robotic system will be far less prone to error; When soldiers are stressed or tired, they are more likely to miss, incorrectly evaluate a situation, or even friendly fire. For reasons like these, a robotic solution may be capable of reducing the amount of casualties, while at the same time potentially being more effective." While Darius understands that reducing the number of casualties is a good thing, and can even further prevent loss of life by lowering the potential for further insurgents to enter the fight, he is still against working on a fully automated system that can take someone's life.

Previously Darius had only worked on automated systems that either prevented loss of life, such as bomb defusal robots, or were simply used as tools by soldiers, such as recon robots. His increasing discomfort in straying any further from these applications leaves him with a difficult decision to make: He either continues to work, and aids in creating something he does not want to exist, or he quits his job and is forced to find work elsewhere, which would put him in a dangerous position in the current economy. Additionally, Darius could go one step further and actively protest against the creation of such automated applications, which would most likely result in him being fired, but would also make it even more difficult for him to get a new job, as he has seen how difficult it is for whistleblowers to do just that.

What are Military Robots?

Military robots are autonomous platforms used by the military for a variety of roles. Currently, military robots take non-lethal roles, such as disposing of live explosives or being used as reconnaissance tools by soldiers. Automated defense systems such as the Samsung SGR-1 do now exist though, and are capable of autonomously firing a weapon, though the SGR-1 in particular is stationary. Aerial drones are currently used as well, though they do not operate entirely autonomously. Some missile systems, for example, have an autonomous portion of their usage, i.e. a missile package that is capable of splitting up and seeking out individual targets.[2, 3]

Discussion Questions

Click the + on the right of a question to view related perspectives and potential starting points for considering these ethical concerns.

Should an autonomous system have the ability to take a human life without any human intervention? If so, how might this affect legal and ethical concerns in other domains or robotics where loss of life is accidental? Additionally, to what degree of certainty must the system reach before it is allowed to 'take the shot', or whatever it may be?

- One possible opinion is that autonomous weaponry of this type should not exist whatsoever, and this opinion has been urged upon the UN.[11]

Military equipment that is already in use, such as a land mine[2], has the potential to kill without human intervention, and it has no knowledge of who triggers it. It can be argued that the land mine has some form of agency, do we treat robots the same way? How can it be acceptable for a land mine to kill someone, but not acceptable for a robot to?

- "However, in general, traditional weapons have a very low autonomous power compared to the new generation of military robots." [2]

If the actions of the robot result in a wrongful death, who is responsible for this? If this responsibility is shared, how much is each associated party responsible?[2, 6, 9]

- Responsibility for cases such as this can be defined as a 'chain of responsibility', wherein any member associated with the decision that lead to the incident holds some amount of responsibility. Politicians may be responsible at a higher level, military commanders at a level below that, soldiers at a level lower still, and the robot itself at the lowest level.[2]

These robots will need to use what data they can gather from the environment in order to make decisions, including who it is they are attacking.Given that biases, particularly racial biases or others based on physical appearance, are already common, how much would this affect these robots and their decisions?

- Facial recognition can become increasingly inaccurate when identifying people of specific minorities[21]. Mistakes that come from such an inaccuracy could potentially involve the loss of life of a completely unrelated party.

The ease of use of these robotic systems may make it even easier to carry out terror attacks. Should governments ensure that these systems do not become accessible to independent individuals and groups? [4]

It is possible that a military robot may be produced with some vulnerability in programming, and is then able to be hacked by someone. If there is loss of life related to this incident, is it the fault of the manufacturer? [4]

Does the lack of human error[19] justify the use of automated soldiers, if they prove to be better at preventing the deaths of noncombatants?

- Precision can be an important factor when it comes to war; "needlessly harming innocents can turn the populace against the counterinsurgency"[22], reducing these needless casualties can in turn prevent further deaths in the future.

Themes

Learn more

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Industrial Robotics

Story

Year 2030:

Sam is working as a cigar roller in Florida, A job that she has had for the past few years and is good at, though these skills are not easily directly transferable to another job. In the past, Torcedors (cigar rollers), were predominantly female, and this has stayed true to this day, as most of Sam's coworkers are also female. Up until recently, hand rolled cigars were revered for the high level of quality they exhibited, however, as automation becomes increasingly adept at achieving the same results, the value of hand rolling lessens to the point where many Torcedors working with Sam begin being laid off, and their work has been automated.

Sam notices that, even considering the smaller number to begin with, her male coworkers have been replaced far less frequently than her female coworkers, on top of the fact that most of the non cigar-rolling jobs at her workplace already are male occupied. After a year, she ends up being laid off as well, alongside a number of coworkers. Many of Torcedors, Sam included, are part of a group chat that they continue to use even though they are no longer coworkers, and a number of them express frustration after losing their job.

"How is this even legal? It's ridiculous..."
"Not only legal but it might as well be encouraged. Have you even seen how much automation is incentivized?"
"Well that's what happens when legislation is decades behind. God forbid the government is proactive with protecting our livelihood"
"I guess we all just need to get robot handling jobs instead, since we 'unskilled laborers' are all capable of doing so"
"Well that worked just fine for Jim and Victor"
"Yeah I wonder why, lol"

Sam's feelings mirror that of her coworkers, and she often finds she needs to ignore the chat to avoid getting angry when the topic is brought up. Knowing that the difficulty she, as well as others, are going through at the moment is avoidable only makes it more annoying, and she finds herself wishing that she were able to help prevent this from happening to others. Though she knows it will be difficult, she decides that she would like to campaign for more worker friendly policies in the face of automation.

What are Industrial Robots?

Industrial Robots are, in general, any type of robot that is used in manufacturing. Their form is typically suited to exactly the kind of motions and workload they are expected to handle in regular operation. These robots are typically employed to do tasks that have a high degree of repeatability or 'routineness'[1], such as picking and placing objects, or aiding in the assembly of parts. Industrial robots have the potential to increase efficiency and quality, while–on the downside–'taking' jobs that would otherwise go to people. While industrial robots do displace work, they also create work in other forms such as designing, operating, or maintaining these robots. This can help lessen the negative impact of job displacement.

Discussion Questions

Click the + on the right of a question to view related perspectives and potential starting points for considering these ethical concerns.

Will automation on its own be able to counterbalance the amount of jobs that it displaces with an equal, or greater number of new jobs?[5, 6]

- "In the 19th century, as automation of some tasks was ongoing, other technological developments generated employment opportunities in new occupations. These included jobs for line workers, engineers, machinists, repairmen, conductors, managers, and financiers"[6]

If automation will not result in more jobs, will there be a feasible way to implement policy, or some other incentives to ensure that there is not a net loss in jobs?

- "These interventions might include removing incentives for excessive automation (such as the preferential treatment of capital equipment) and implementing new policies designed to rebalance the direction of technological change"[6]

For workers displaced by automation who are also able to get one of the new jobs that is supported or created by automation, will this process be quick enough that they would be able to get right back to work, or would they still be displaced for a considerable amount of time?

In the time period between the automation being implemented, and the additional jobs that arise from that automation, should the workers that have been displaced have some sort of financial compensation to ensure they stay on their feet until they are able to get one of the new jobs?

- This, along with many of the following questions has the potential to be solved with the right kind of automation policy by the government in order to ensure those displaced by automation are not too adversely affected.
- Alternatively, should employers be incentivized to provide job training to workers who are going to be displaced? For example, someone who will lose their job to a technology is able to receive job training to be able to maintain that technology, and therefore is able to keep their job at that company.
- As we get more and more capable of automating complex tasks that were previously considered unfit to be done by robots, and the realm of jobs that are untouched by automation dwindles, would something like a universal basic income be necessary? Would an idealistic financial world even be feasible?
- For people who are privileged enough to make more money than they need to, should there be a societal obligation to accept a lower salary in order to allow for the possibility of more workers, ideally those who have been displaced by industrial robots?

Automation, like in the case of the story, can disproportionately displace groups that already face disadvantages in the workplace[1]. How will we ensure that, for all people who are displaced by automation, we are able to provide an equal opportunity for work elsewhere, as well as ensure that already disadvantaged groups aren't being displaced more rapidly than others?

- Some jobs with higher numbers of female workers are "more insulated from displacement by technology"[1], meaning there is the potential for this to naturally offset disproportionate displacement elsewhere.

In some cases, the work that a human does might be very harsh on their body, or have other severe consequences to their health. If this process is able to be automated, is it better that they have the opportunity to work a job that will harm them, or is it better that they are put out of work, and are able to better maintain their health?

Themes

Learn more

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Appendix H - Home Page Content

Home

In modern society, technology is developing at a fast speed. Among emerging and growing technology fields, robotics is perhaps the most eye-catching one, as it brings infinite possibilities to our lives, and its real-world applications closely connect with every single aspect of human life. As robotic technologies become more integrated with ourselves and society, many new ethical concerns arise.

This website is created by WPI students for an Interactive Qualifying Project to provide a learning experience in a range of ethical issues in different domains of the robotics field. For each domain, you can view ethical questions, themes, resources, and principles for ethical practice. Each page also includes a comment section to discuss ethical issues with other site visitors. The robot domains discussed in this website include military robotics, humanoid robotics, biomechatronics, distributed robotic systems, surgical robotics, domestic robotics, industrial robotics, and companion robotics. The themes explored are human rights, accountability, transparency & explainability, government, professional responsibility, fairness & non-discrimination, human control of technology, identity, promotion of human values, safety & security, and anthropomorphization.

Appendix I - About Page Content

About Us

This site is created by Brian Desousa, Kaitlyn Fichtner, Yaru Gong, and David Rodriguez foran Interactive Qualifying Project at Worcester Polytechnic Institute in 2020-21. The project was advised by Professor Yunus Telliel (Humanities and Arts) and Professor Berk Calli (Robotics Engineering). , This project aims to educate and inform undergraduate and graduate students of real world issues in robotics that may become prominent in coming years.

About Our Site

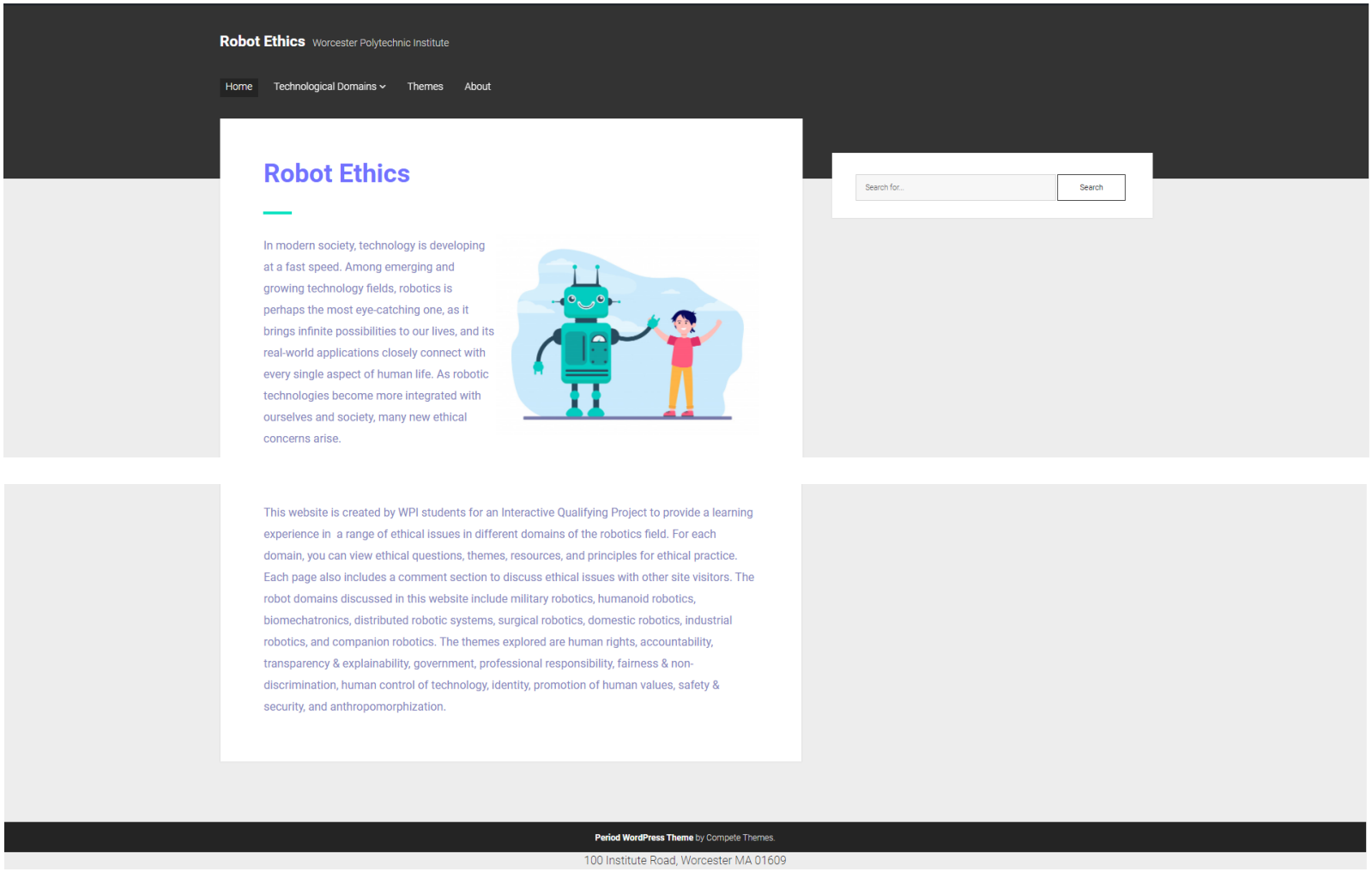
This site is intended as a starting point for anyone who is interested in robot ethics. The goal of the site is to help readers better understand and talk about ethical dilemmas our society could face in the near and semi-distant future. Additional sources are also provided for those who seek to do more reading or gain a deeper understanding of a specific area in robotics. By providing a framework for roboethics and a conversation platform, our hope is that the site's visitors will begin to discuss possible dilemmas and solutions, so as a society we can be prepared to face these issues and work proactively rather than reactively. The theme page introduces ethical themes related to robotics, as we would like to give a holistic understanding of the major questions in roboethics.

Disclaimer

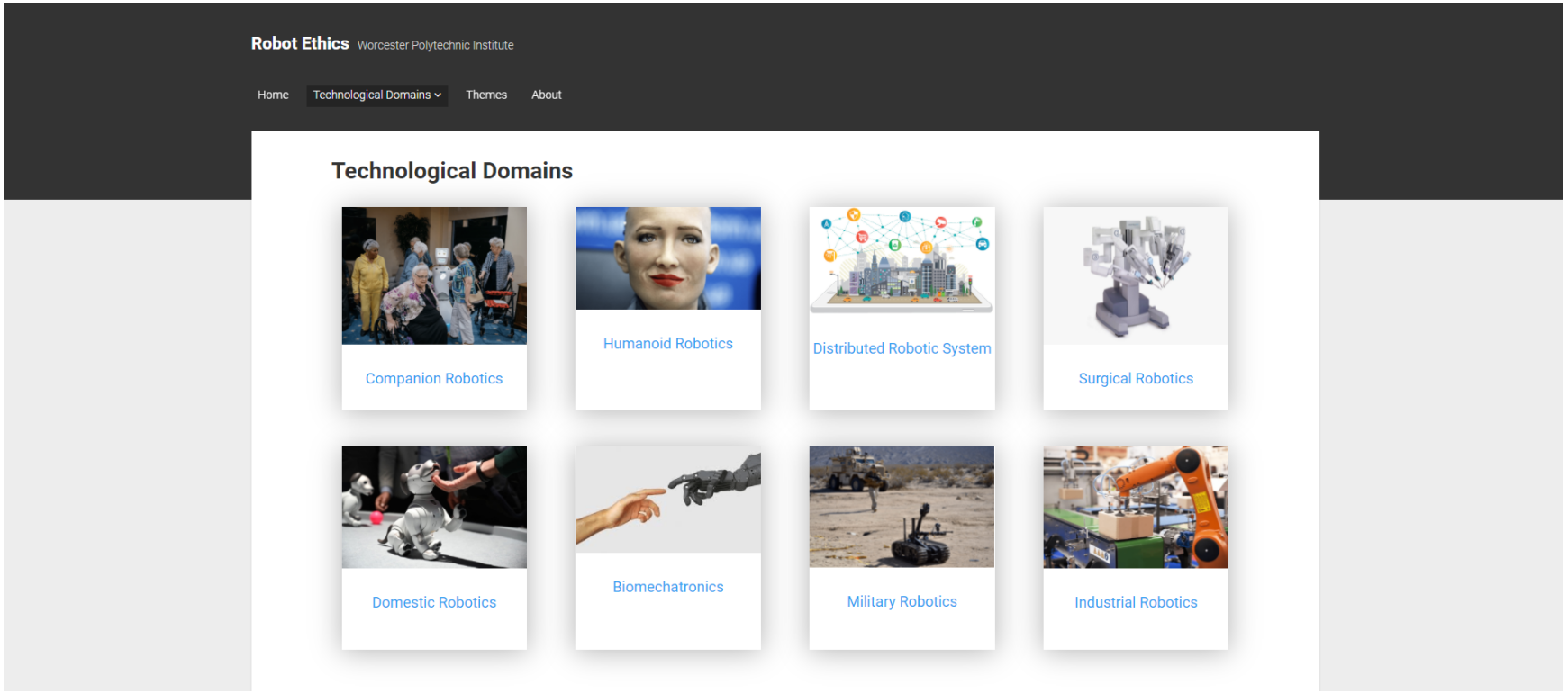
While the stories given for the technological domains are rooted in research on those topics, it is impossible to predict with perfect accuracy what problems may actually appear. In the hopes of allowing a better understanding of the kinds of nuance these situations may have, these stories sometimes are slightly exaggerated or contain situations that may be unlikely even if plausible.

Appendix J - Website Design

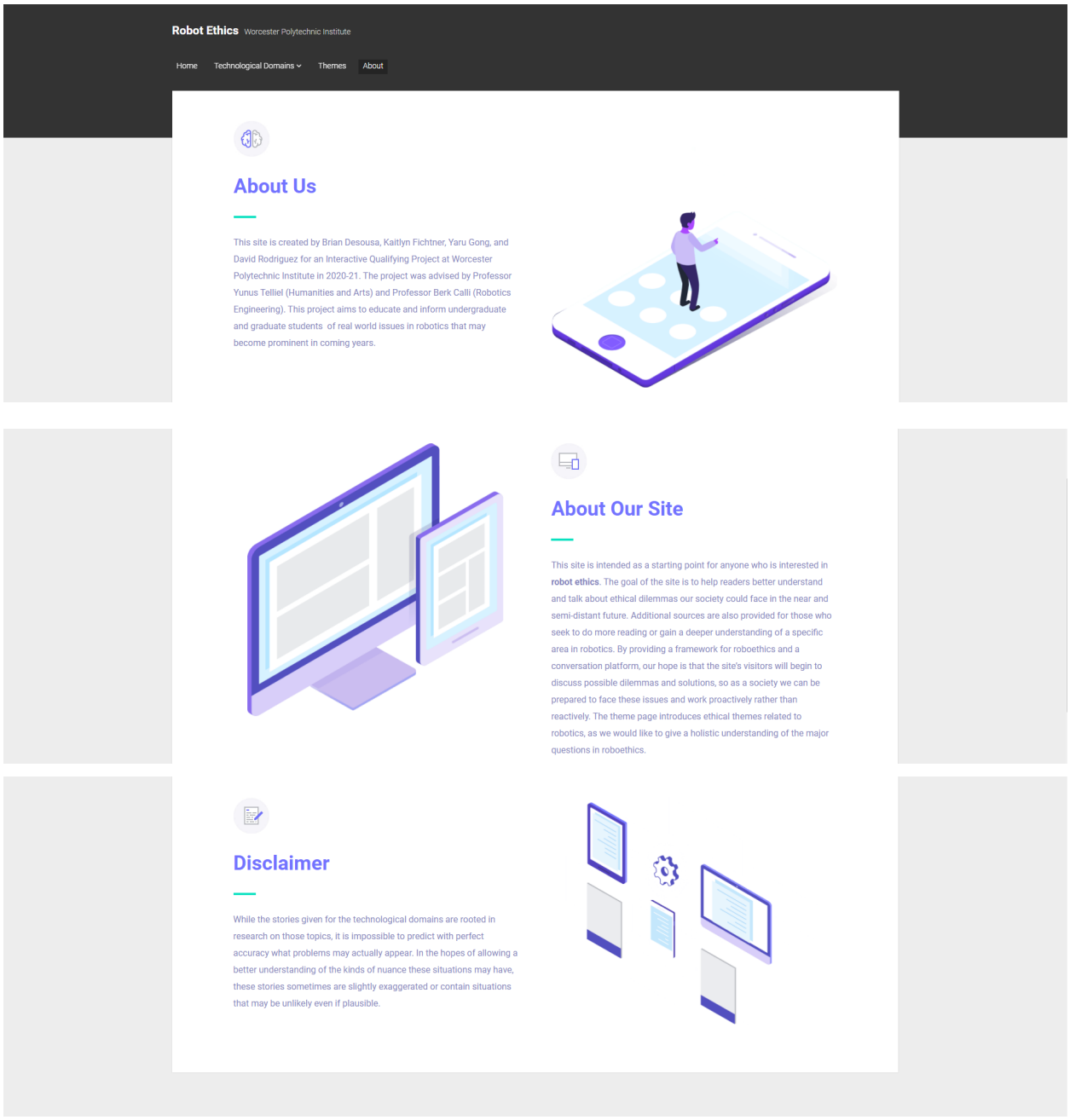
Home Page



Domain Gallery



About Page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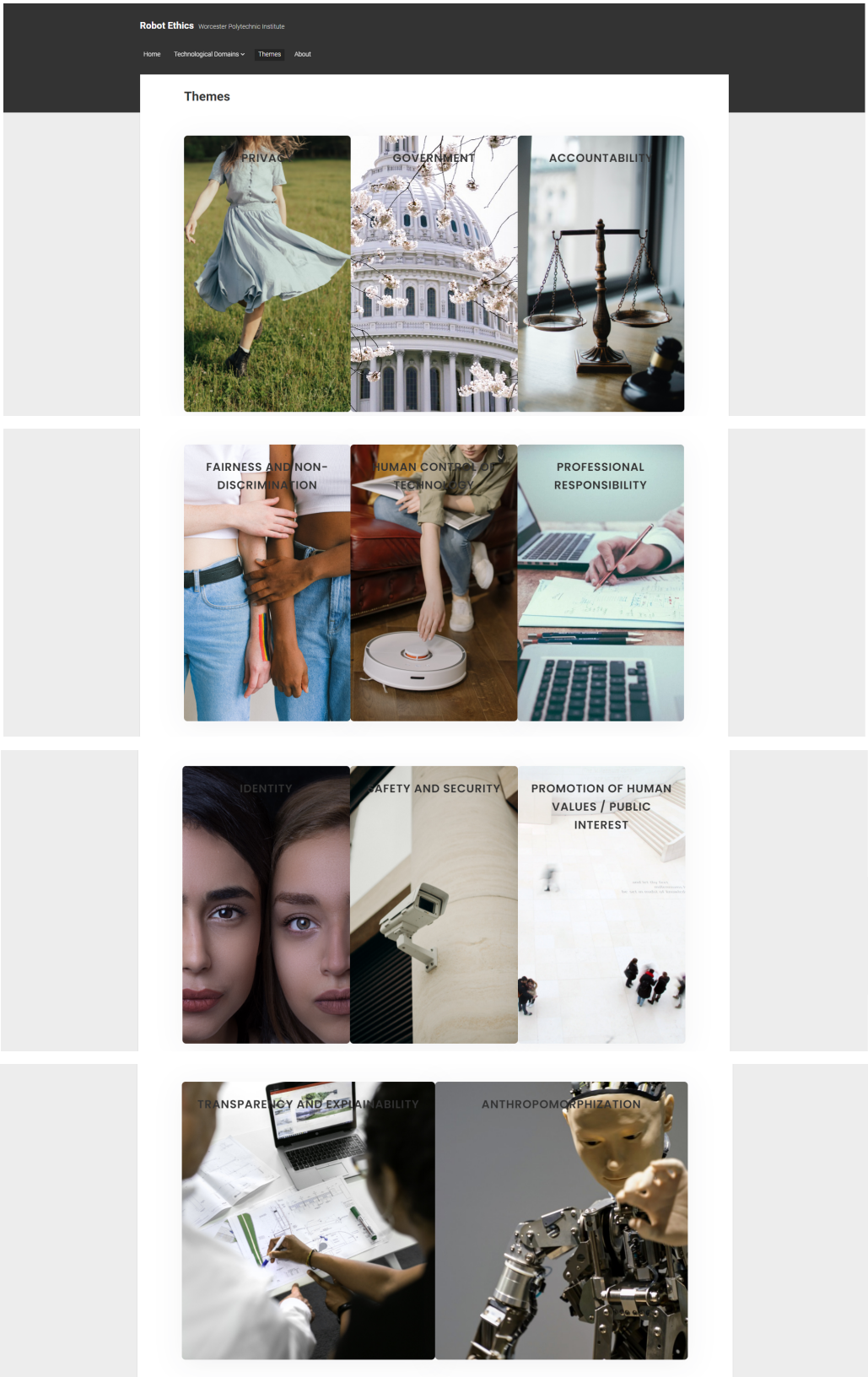
About Us
This site is created by Brian Desousa, Kaitlyn Fichtner, Yaru Gong, and David Rodriguez for an Interactive Qualifying Project at Worcester Polytechnic Institute in 2020-21. The project was advised by Professor Yunus Telliel (Humanities and Arts) and Professor Berk Calli (Robotics Engineering). This project aims to educate and inform undergraduate and graduate students of real world issues in robotics that may become prominent in coming years.
About Our Site
This site is intended as a starting point for anyone who is interested in robot ethics. The goal of the site is to help readers better understand and talk about ethical dilemmas our society could face in the near and semi-distant future. Additional sources are also provided for those who seek to do more reading or gain a deeper understanding of a specific area in robotics. By providing a framework for roboethics and a conversation platform, our hope is that the site's visitors will begin to discuss possible dilemmas and solutions, so as a society we can be prepared to face these issues and work proactively rather than reactively. The theme page introduces ethical themes related to robotics, as we would like to give a holistic understanding of the major questions in roboethics.
Disclaimer
While the stories given for the technological domains are rooted in research on those topics, it is impossible to predict with perfect accuracy what problems may actually appear. In the hopes of allowing a better understanding of the kinds of nuance these situations may have, these stories sometimes are slightly exaggerated or contain situations that may be unlikely even if plausible.

Themes Page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Themes
PRIVACY
GOVERNMENT
ACCOUNTABILITY
FAIRNESS AND NON-DISCRIMINATION
HUMAN CONTROL OF TECHNOLOGY
PROFESSIONAL RESPONSIBILITY
IDENTITY
SAFETY AND SECURITY
PROMOTION OF HUMAN VALUES / PUBLIC INTEREST
TRANSPARENCY AND EXPLAINABILITY
ANTHROPOMORPHIZATION