Urgency Ethics in Robotics

Applied Robotics Ethics Lab

by

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Urgency Ethics in Robotics

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Abstract

This project examined the applied ethics of robots during the COVID-19 pandemic. Focusing on the four major ethical principles (privacy, safety and security, fairness and non-discrimination, and transparency and explainability), this project mapped potential ethical issues that emerge from the deployment of robots and other autonomous systems in crisis situations such as the COVID-19 pandemic. The project also analyzed ethical issues in the robotics response to the Fukushima Daiichi nuclear disaster and provided insights for a comparative framework of urgency ethics in robotics.

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1. Introduction

"Roboethics," has recently become an expanding debate in the robotics world since the First International Symposium on Roboethics in 2004. Roboethics is commonly understood as the area of study of robots' moral conduct. According to Khatib and Siciliano (2017), "roboethics is not the ethics of robots, nor any artificial ethics, but it is the human ethics of the robots' designers, manufacturers, and users" (p.2140). Unlike sci-fi novels or movies where robots are imagined with moral agency, humans that design and develop robots are the ones that impact the rest of human lives. Roboethics was created to identify and analyze ethical issues in robotics applications and to define general guidelines for those applications. A general moral imperative for robots is echoed in one of Isaac Asimov's laws, the Zeroth law, which indicates that a robot may not harm humanity, or, by inaction, allow humanity to come to harm. This law set the guidelines for robotics and AI and has been the main scope in the roboethics debate. If a robot or an AI system were to harm humans, immediate reconsiderations take place determining how much these robots and AI systems are needed and if it is worth implementing in the time being. It is important, however, to know that harm is not necessarily restricted to physical mischief, it includes invasion of privacy and security by deployed technologies, socio-economic inequality presented by biases embedded in artificial intelligence (AI) frameworks, or even safety threats by potential AI arms race (Thomas, 2020). The harm caused by robots and AI is a broad concept that the roboethics domain has been working on to identify the possible means of harm.

In the course of recent years, robots have presented a bright future to many in the world; likewise, they presented a whole bunch of ethical debates and concerns. Automation and AI are yet to be fully comprehended and developed, but as global catastrophes such as the current novel coronavirus pandemic rise, a pattern of immediate calls for robots saving up the day ascends along too. This prompted ethical debates on the urgency of AI and robots as various global organizations and governments started to fund and support engineers and roboticists to develop emergency response robots.

When the COVID-19 pandemic hit in 2020, lockdowns and social distancing restricted many daily life activities. The dread of contracting the virus that has taken the lives of more than half a million right up until the present time, made social interaction a threat to all human beings as humans became both the victims and the main carriers for the virus. Many businesses started to shut down, and humans started to lose their jobs (Borenstein & Howard, 2020). Schools and institutions closed their campuses and moved online, and a record number of students were forced to leave their dorms and sent to their homes. Health workers became at a constant risk of getting infected and ceaselessly required to make life-and-death decisions over the virus (Khan, 2020). However, the virus does not present any risk to robots and the latter are able to operate tirelessly without any breaks (Purtill, 2020). Hence, a proposed solution was to automate a significant part of the essential workers' jobs to reduce the risk of contamination and carry on with many daily tasks. However, as technologies are urgently being deployed, growing concerns over the use of AI and data in response to the coronavirus outbreak raised many ethical issues and risks that, as described by HÉigeartaigh et al. (2020), cannot be overlooked.

2. Background

"As epidemics escalate, the potential roles of robotics are becoming increasingly clear," said an international group of researchers on the COVID-19 pandemic (Purtill, 2020). Although global disasters differ in their nature, there has been a common interest to deploy robots to solve problems emerging from such disasters. This project investigated the question of *urgency ethics* as it applies to the use of robots and AI during an emergency. Before I move to my discussion of urgency ethics, I want to contextualize it as part of current conversations regarding robots, AI, and ethics.

2.1. Robotics vs. Artificial Intelligence vs. Machine Learning

As artificial intelligence (AI) is spreading worldwide in real-world applications, many people still don't understand what AI is. However, robots are becoming a bit more familiar to a larger number of people, yet many even do not know the difference between a robot and a machine.

2.1.1. Robotics

Robotics is defined as a branch of technology that deals with robots (Balajee, n.d.). A robot is a programmable, self-governing machine capable of carrying out a series of tasks and making decisions without an external trigger. On the other hand, a machine requires to be operated by a human in order to act. Robots are mainly designed to perform tasks considered to be dull, dangerous, and dirty for human beings. A robot could be autonomous if it is capable of performing tasks without requiring external control of teleoperation. During the process of designing, building, and programming autonomous robots, only a small level of artificial intelligence is embedded within their system.

2.1.2. Artificial Intelligence & Machine Learning

Artificial intelligence (AI) is a branch of computer science that simulates human intelligence in machines in order to carry tasks that would otherwise require humans (Balajee, n.d.). AI is referred to as any machine exhibiting any traits of the human mind. AI algorithms have been proven to successfully tackle learning, problem-solving, logical reasoning, and perception. The main goal behind AI is to allow computers and machines to operate in an intelligent manner. AI works by combining numerous data through an iterative process with the aid of algorithms to enable the software to learn from patterns in the data. AI programs used to control robots are usually a subsequent part of the sizeable robotic system, including actuators, sensors, and non-AI programming.

On the contrary, machine learning is an AI-based application allowing machines to access data and learn by themselves. The bridge between the branch of robotics and AI is what has recently been known as artificially intelligent robots, which are robots controlled by AI programs. In this report, my focus will be on AI and robotics while ethical issues related to machine learning will be briefly introduced.

2.1.3. Robot & AI ethics

Robots and AI have raised fundamental questions on their advantages and risks, rules and limitations, ways their applications can be utilized, and control over them. Ethical issues for autonomous and non-autonomous robots and AI systems are contingent upon specific uses of these technologies. In addition, the design of technical artifacts has ethical relevance for their use (Houkes & Vermaas, 2010). Therefore, the ethical issues of robots and AI also depend on their design. Robot and AI ethics tend to address problems with no current solutions. The trolley dilemma (e.g., whether overrunning a person is permissible to avoid the possible death of others) is a topic in many roboethical debates; its goal is to think about the consequences of an action and its moral value. The dilemma is that if a person with a switch control to the running trolley's rails sees five children playing on the tracks of the trolley's direction and one child playing in the sidetrack, should the person pull the lever or not? If the person decides to continue in the trolley's main rail track, they risk the lives of five children, but if they pull the lever to the side track, they risk the life of only one child. These ethical discussions usually determine the guidelines and limitations for both robots and AI.

Robots have also generated debates on the impacts of automation. In case of a global health disaster, where social distancing is required, and no vaccine has been developed yet, should meat slaughterhouses replace their human workers with automated robots to continue producing meat or stop their production affecting the country's supply chain? In case they automate their productions, people will lose their jobs, and if they decide to continue with human workers, they risk a more extensive spread among workers and their families. These types of questions usually also arise in AI systems and their applications. Technically, there is an overlap that makes it hard to distinguish between robotics and AI research. Since more robots are becoming autonomous and due to the substantial overlap between both fields, AI discussion has generated more interest compared to robot ethics. Scholarly interest and push towards AI ethics are much more rigorous considering the broad range of disputes rising from its implementation among many sectors. AI ethicists identified four principles as a reference to evaluate ethical discussions in robots and AI, which are privacy, safety and security, fairness and non-discrimination, and transparency and explainability. Because of the convergence between AI and robots ethical discussions, I decided to investigate robot ethical considerations in terms of the four AI principles in my research.

2.2. Urgency Ethics

"Without a sense of urgency, desire loses its value," says Jim Rohn, an American entrepreneur. The word “urgency” flags the need to respond quickly and act fast. At the point when a situation is urgent, it means that an individual or an environment is at impending risk of encountering an emergency in the near future if intervention did not forestall a worsening of the situation. In the past, and up until recently, communities would reach out to essential workers such as health workers, soldiers, engineers, and so forth when they require an urgent intervention to resolve a crisis. However, disasters expose those first responders to risks, sometimes causing more harm than the disaster has already caused. Recent disasters that presented extensive harm to human responders pushed engineers and roboticists to build emergency response robots. These robots usually possess certain characteristics such as high strength manipulation, robust locomotion ability, harsh interaction ability, and considerably more incorporated characteristics built to help during the execution of disaster relief tasks. Artificial intelligence tools implemented in these emergency response robots, as well as frameworks utilized by the governments, have raised numerous concerns. Though these AI tools can help spare the natural environment, businesses, and the lives of various individuals, the need to implement solutions quickly raised ethical discussions.

At a time when AI is offering the potential for widespread real-world applications, there are growing concerns on the utilization of AI and big data in light of global catastrophes. These concerns include transpassing civil liberties and people's privacy to gather data that are later processed by corporations and governments. This raises an ethical debate on which type of technologies and frameworks should be deployed each time an urgency hits. Sometimes robots or technological interventions are not the best solutions to the problem; however, at some other time, a problem can only be first encountered by robots for humans to develop innovative ways to solve the problem. Hence, with each disaster, an unprecedented opportunity to leverage AI for societal benefits is presented (HÉigeartaigh et al., 2020). It might take time until AI fully grasps hold of future disasters, but until that time comes, it is important not to overestimate as well as underestimate its potential.

In this project, two crises were presented in this report. They were examined through the lens of the ethics of urgency: the COVID-19 pandemic and the Fukushima Daiichi nuclear disaster. Both of these disasters received reactions that are similar in some ways and different in other ways. My discussion also takes into account that from the time the Fukushima Daiichi disaster occurred in 2011 until the COVID-19 pandemic took place in 2020 there have been numerous technological advancements and a global surge of awareness regarding robotics and AI. The next section introduces the ethical issues related to the deployment of robots and AI during an emergency.

2.3. Ethical themes: AI Principles

In a recently published work from the Berkman Klein Center for Internet & Society Research at Harvard University, a team of researchers summarized the main principles for using AI in a wide-based project that took around two years. As decribed by Achten et al. (2020), eight key themes are central to current conversations on AI ethics: privacy, accountability, safety and security, fairness and non-discrimination, transparency and explainability, human control of technology, professional responsibility, and promotion of human values. Their work served as the main reference to this Interactive Qualifying Project (IQP).

2.3.1. Privacy

Privacy is defined as preventing an unauthorized intrusion into one's very own data. According to Achten et al. (2020), there are two main aspects of AI that are of particular relevance for privacy: the ability of software to settle on decisions all alone, and the ability for a framework to develop all alone by learning from experience. The first aspect is known as AI-driven decision making. Companies worldwide have adopted a data-driven approach for their operational decision-making until they realized the need to invest more AI into their workflow to make their systems faster and more reliable (Colson, 2019). It is essential first to understand the difference between data-driven and AI-driven decision making. Data-driven decision making captures volumes of data like motions, transactions, and other data that'd help make a better decision, and yields it into databases, libraries, or other similar file systems that are further processed by human beings. This reduces the time devoured by humans to perform these tasks manually and summarizes the large volumes of data to become easily comprehended by humans.

On the other hand, AI-driven decision making leverages the most beneficial information towards making the best decision from the collected data and determines which financial investments to make, ad is most effective, or other tasks that require the process of settling on a choice (Colson, 2019). The purpose of an AI-driven workflow is to improve efficiency and capabilities as opposed to reducing costs or replacing human beings, commonly perceived as automation. The second aspect, referred to by the published work at the Berkman Klein Center, is known as reinforcement learning (RL). RL is an archetype of machine learning based on the notion of training machine learning models to make a sequence of decisions (Budek & Osiński, 2018). It is worth noting that as RL is becoming progressively complex and getting snared to increasingly "cognizant" brain-like operations. It is turning into an undeniably critical discussion in the scope of robo-ethical debates. Usually, privacy ethical threats discussions prompt the discussion of the previous two aspects.

Facial recognition, the most dreaded technology in the US, has had much of an echo over the recent years (Ghaffary, 2019). Perhaps the most famous scandal for the unauthorized utilization of this system is the Facebook scandal. In 2006, Facebook was first censored when it neglected to inform users and get permission for its newly launched feature “News Feed.” It prompted privacy concerns as Facebook did not tell users how their privacy settings influence what other users would see. This was only the beginning of a progression of infringements the company had taken against users’ privacy. The most recent issue with Facebook is its facial recognition feature. In 2019, Facebook reported that it would be turning out facial recognition settings to all users and turning it off to all new users. Facebook’s innumerable misconduct of users’ privacy and consent raised numerous ethical concerns and public disputes.

Consent references the notion that a person’s data should not be used without their knowledge and permission (Achten et al., 2020). A person should have the right to erase and ratify their data, control over the use of data, and restrict processing. As AI evolves, it augments the possibility of intrusion into one’s privacy by raising the analysis of personal information to new levels of power and speed (Kerry, 2020). With that in mind, the question now becomes: How do AI-driven decision making and reinforcement learning threaten privacy? According to Rodriguez (2020), supervised and unsupervised learning techniques are applied to meet users, predict subscriber likes and behaviors, and identify system failures. These learning techniques require a large amount of historical data to carry out such tasks. Historical data collected are then stored in databases, where a person’s actions have all been recorded. The time these data are kept is unknown, and people cannot erase or ratify their data from these large databases. These learning techniques also raise transparency and fairness concerns. What type of task people’s information is collected for is not communicated to the public by these AI frameworks and companies. In addition, in case a company is applying the learning technique to create an ad according to customers’ tastes, the information is not enough (Rodriguez, 2020). Therefore, “informative databases,” collect data from several consumers and historical datasets, reflecting historical and social inequities resulting in biases in the AI system.

2.3.2. Safety and Security

In 2017, an autopilot car that belonged to Tesla, a leading company in electric cars, caused a fatal accident that raised fear and numerous debates on AI's safety. The National Transportation Safety Board (NTSB) recently found that Tesla's semi-autonomous driving feature was partially to blame (Chokshi, 2020). The company's autopilot feature drove along a highway in California over 70 miles an hour when it struck a concrete barrier and caused fatal injuries to the driver (Heilweil, 2020). After the investigation, it was found that the driver was engaged with his phone and did not notice the car steering off the path. Nevertheless, half the blame also goes to the autopilot car. The car alerted the driver very late that the driver's response to try to mitigate the severity of the crash or avoid it was nearly impossible. The NTSB then suggested a better system for autopilot cars that senses the driver's engagement and alerts them. Autopilot cars offer a level of convenience to drivers; nonetheless, they also come with their risks. Although autopilot cars are self-driving cars, humans' constant monitoring and action is still required. As it could be drawn from this accident, AI systems are still not able to make decisions when faced with an unpredicted situation. The autopilot car did not stop nor recorrect its path when it steered off the path and came across the concrete barrier. Its ability to make a decision was not fast and reliable enough, and due to the driver's engagement in another activity, the car proceeded with what it was doing after no feedback was sensed from the human driver. This leads to the question of how safe AI systems currently are?

According to Achten et al. (2020), the safety principle requires an AI system to be reliable enough to do what it is supposed to do without harming living beings or the environment. Security, on the other hand, is the ability of an AI system to resist external threats. Safety and security are usually related to each other; one is expected to ensure the other. Security in AI frameworks is usually seen in the form of protecting personal information. How much a system is secured depends on the resilience of the AI system and its ability to secure information on vulnerabilities from cyberattacks. It also depends on its ability to protect the privacy and “the integrity and confidentiality of personal data” (Achten et al., 2020). Both safety and security principles could be developed by improving the predictability of a system and developing secure systems by its design. In the case of Tesla's Autopilot car, the software was only able to detect and respond to situations it has been programmed and trained to deal with. Therefore, it never detected a crash, causing the car to accelerate and hit a barrier. This incident - one of many - calls on the importance of rigorous testing for safety and security before implementing AI systems.

2.3.3. Fairness and Non-discrimination

In January 2019, Joy Buolamwini, a researcher at MIT, identified bias in three of the latest facial recognition software developed by Microsoft, Amazon, and Megvii (Vincent, 2019). The software was found to successfully identify a person's gender from a photograph, 99 percent of the time, except it was only of white men. The accuracy dropped to 35 percent for women with darker skins. The facial recognition technology presented higher rates of error for minorities, particularly women, due to the unrepresentative data. Logarithmic biases are not only seen in gender, race, or age factors, but machine-learning algorithms also pick up hidden biases that, as per Dickson (2020), are "difficult to identify" but "equally damaging" factors. Biases are embedded into AI frameworks by humans; therefore, it is a human's responsibility to stop discriminating against a group of people to stop impacting AI systems by encouraging the public's mistrust in AI because of distorted results. To do so, it is essential first to understand and measure fairness. How much fair is fair enough? — a question that led researchers to develop technical ways to define fairness. For instance, DeepMind, earlier introduced as a company that uses RL for its software algorithms, developed a path-specific approach to counterfactual fairness (Manyika, 2019). The model was developed to help ensure a fair application process in university departments enrollments. These improvements will help determine whether a system is fair enough to be released or not through a series of tests and trials. Finally, fully-automated decision-making requires to be reviewed by multi-disciplinary fields professionals, such as humanities thinkers, ethicists, roboticists, entrepreneurs, developers, and engineers, before made permissible.

2.3.4. Transparency and Explainability

Transparency is connected to both the safety and security and the fairness and non-discrimination themes. According to Achten et al. (2020), transparency and explainability are a foundation for the realization of many other fields. Transparency is defined as the possibility of oversight over AI systems operations. Furthermore, explainability is the translation of technical concepts and decision output into intelligible comprehensible formats for evaluation (Achten et al., 2020). There are many types of transparency, depending on the goal of the developer, deployer, and the user. Transparency has positive effects on societies. For instance, for a user to understand how a system works and its purpose, the user could predict what the system can and cannot do; therefore, helping the society build trust in AI and overcome the fear of the unknown. In addition, when transparency makes users feel safe and comfortable to keep using a system, deployers benefit in various ways. Transparency is also vital for developers to detect errors and unwanted flaws, such as biases in machine learning algorithms, and work on fixing them. Hence, the transparency principle withholds which party the system is designed for opposed to which party benefits from the system. Transparency can be an ambiguous principle; a lot of ethical discussions that ought to explore transparency end up also examining privacy, safety, security, fairness, and explainability principles. It is a broad concept that is often not communicated correctly, resulting in the public's mistrust and organizations' unethical usages. Developing transparent algorithms helps explain and inspect how decisions are made, and data is used. Yeo (2020) states, "there are many types of transparency with different motivations, so we must find better ways to articulate and measure them precisely."

2.4. Cultural Perception of Technologies

As the world is shifting to rely more on AI and robotics, it is essential first to increase a society's solace level and trust in technologies. How the world perceives technologies and how cultures affect people's views on technology was important to understand parts of this project. Throughout this project, numerous readings and discussions concluded that cultures play a crucial role in how a particular community perceives robots, AI, and technologies. In Japan, for instance, robots are accepted as part of society and often offer hope to the 21st century compared to the West's fear of such technologies. Beliefs and rituals of Shinto and Buddhist religions, historically dominant cultural forces in Japan, have contributed to the Japanese society's acceptance of robots. In "*Why Westerners Fear Robots*," Tezuka, a Japanese manga artist, cartoonist, and animator is quoted:

> Japanese don't make a distinction between man, the superior creature, and the world about him. Everything is fused together, and we accept robots easily along with the wide world about us, the insects, the rocks—it's all one. We have none of the doubting attitude toward robots, as pseudohumans, that you find in the West. So here you find no resistance, simply quiet acceptance (2018).

Tezuka indicates that the constrained concept of "humanity" in the West is due to the differences in religious and historical contexts in the region. Thereby, before organizations begin to rely more on AI and machines, they should first understand their own cultural and social context.

People’s perception of technologies could put a specific use of technology at stake. Take the difference in reactions after the drones implementation in each of Japan and the US as an example. The first ever drone was deployed in 2006 in the Democratic Republic of Congo to assist with surveillance missions (Karlsrud & Rosén, 2013). In 2010, the drones offered a great help with combating Haiti’s Earthquake effects, which led other countries to start adapting the technology as a source of disaster relief. In Japan, the government has been promoting the use of drones (Niekawa, 2019). Drones are viewed as a source of hobby and entertainment in the culture of Japan.; they also have been essential assistants in many of the industrial and medical jobs. Drone owners are required to register for a permit, but the government has not received an ordinance asking to ban drones flying over a public area. On the other hand, in 2013, a Southern California city in the USA voted to boycott drones flights (Herzog, 2013). Fear captured the city’s residents after seeing unmanned aircraft on top of their heads. To them, these drones invaded their privacy and presented a type of warrantless surveillance. In 2014, the California State Senate passed legislation confining law enforcement and agencies to use drones (Mendelson, 2014). The proposed ordinance was to ban unmanned aircraft flying 400 feet above residential zones controlled by a distant pilot or GPS. It also included requiring a “drone permit” and a composed consent from every registered property holder for drones recording over a residence area (Herzog, 2013). It likewise proposed that law enforcement agencies would have to obtain a warrant before flying a drone and that the public agencies could utilize drones to accomplish missions as long as that mission is not to gather criminal intelligence. The principal exemption becomes emergencies such as fire or any other perilous situation. Thus, culture plays a huge role in the reception of robots, AI, and other types of technologies.

Drones flying at low elevations, particularly those equipped with cameras or weapons, have raised fears of inescapable surveillance in the US as organizations have not been transparent enough on what the data gathered by drones are used for. While other communities might have some of these concerns too, the distinction here lies on how communities' opinions towards disaster relief innovations determine the law and the agriculture of their countries. There are a couple of causes that seem to ignite the dread of AI and such technologies in people. Some of these include the idea of mass unemployment numbers, powerful AI falling in possession of wrong individuals, and merely the concern of having super-intelligent machines that could have life and death ramifications. In order to mitigate these cultural and societal fears, it is important to understand the reasons behind such a strong reaction and work on building trust between the public and technologies.

3. Research

This project was established upon a question: What is the right way to think about technology in the midst of COVID-19 crisis? Furthermore, how to approach it? As governments and organizations work towards finding a solution in the fastest time possible, people are more willing to forgo some of their civil liberties to come with a short-term solution to the disaster. However, these short-time solutions might, in turn, present a long-term disaster of another type. Before becoming more reliant on robots and AI software, many critical ethical considerations need to be addressed and encountered.

It is vital to bear in mind that as technology fixes existing problems, it may also create nonexistent problems. Adopting a new technology without carefully analysing its social consequences has had a detrimental effect on many societal issues. Facial recognition technology is a recent and clear example. Facial recognition technology helps law enforcement agencies uncover criminals and find missing individuals (Marr, 2019). Therefore, it fixes security and safety problems. However, the biggest drawback to this technology is that, in most people's opinions, it creates a threat to individuals' privacy. It also has a bias problem, creating a nonexistent problem in AI that needs to get fixed (Ivanova, 2020). Therefore, it was inferred that on certain occasions, utilizing technology is not the best solution to a problem. Nontechnical solutions also solve problems. Hence, a question worth pausing for is: When is the technology required to step into action? And how could it mitigate the impact of a crisis? A recent example taken into account when assessing this project's investigation was the Tham Luang cave rescue.

In 2018, a football team got trapped inside the Tham Luang Nang Non cave in Chiang Rai Province, Thailand. The team, consisting of twelve junior players and their coach, entered the cave after a football practice, and not long after, the cave flooded with heavy rains and blocked their way out to the world. After nine days, the team was found alive by two British divers about 4 kilometers (2.5 miles) away from the cave entrance. Rescue operators discussed various possibilities to rescue the team, and the incident gained worldwide public interest. Elon Musk, the CEO of SpaceX, created a submarine for the team and dispatched it to Thailand to help accelerate the rescue process (Jacobs & Suhartono, 2018). However, due to the cave's narrow zigzag-like paths nature, the designed rigid kid-sized submarine did not prove useful. Instead, it was left aside, and a team of International divers took the risk and worked quickly to rescue the team before the start of a new monsoon season. The massive efforts to locate and rescue the twelve boys and their coach took a total of 18 days, and though there was some involved technology to express gratitude toward, it was a problem solved by a team of brave divers. When asked about Musk's custom-made submarine, Narongsak Osottanakorn, the head of the search operation, stated: "I assure you that the equipment he brought to help us is not practical for our mission. Even though the equipment has state of the art technology, it does not fit our mission in the cave" (Jacobs & Suhartono, 2018). Thus, proving that technical solutions are not always the best solution to world problems. It also proves that technology could be a solution to many of the world problems, but if the approach was wrong, the robotic or technical solution would prove to be useless in a given setting. After investigating the Tham Luang cave rescue incident, I decided to further focus this project on robots and AI ethics amid an emergency.

Another aspect taken into account during the project's research is the public's perspective on technology, particularly during a crisis. It was found that a crucial step to rectify the public's perspective on the technology presented nowadays is communication between the technicians, engineers, roboticists, and the public. It is a roboticist's responsibility to convey the current robot or machine in the most truthful yet appealing way. In order to answer all of the questions, an important step was to explore patterns of incidents where technology was and was not able to solve a crisis.

3.1. Methodology

The goal of this project was to explore applied robotics ethics during the COVID-19 pandemic. Part of this project's goal was to make a more realistic assessment of what technology can or cannot do. To achieve our project's goal, three steps were established in the starting weeks of the project.

1. Identifying robots' role during the COVID-19 pandemic and analyzing ethical discussions raised upon robots and AI deployment
2. Examining robots' role in the Fukushima Daiichi nuclear disaster and analyzing ethical discussions related to robots and AI deployment
3. Determining similarities and differences in ethical discussions marked up by both disasters

The subsequent sections detail the steps of analyzing selected articles and discussions to determine and measure the global response to applied roboethics during the COVID-19 pandemic and the Fukushima Daiichi nuclear disaster.

3.1.1. Identifying Robot Roles during the COVID-19 Pandemic and Analyzing Ethical Discussions Raised upon Robots and AI Deployment

First, we began to explore an incident where robots were able to solve a crisis. In order to ensure a better understanding of the coronavirus outbreak, the following questions were asked:

1. How robotics are (or are not) responding to COVID-19 and its effect on social life?
2. In what ways are robots used during the pandemic?
3. What are the ethical concerns related to the use of robots during and after the pandemic?

To answer these questions, the first step was finding academic and non-academic (news articles, textbooks, and blogs) articles. Due to the COVID-19 pandemic, it was challenging to access the public or faculty members to interview and collect feedback. Therefore, I decided to build my research upon reading and analyzing journals and articles retrieved through Google scholar or search, and WPI databases. The articles' credibility was a critical aspect of the research, as information from these articles will impact and determine the next steps of the project's research and discussions. The majority of the chosen articles discussed the ways robots have been utilized worldwide to assist during the pandemic, in addition to the new ethical concerns brought to light by the coronavirus outbreak. The second step was to create bibliographic information about the articles. The third step was to annotate the articles. The annotations incorporated the author's background, the scope of work, main argument, and employed methodology and research methods. Upon my research, I likewise considered the author's perspective, methodology, and theoretical framework, in addition to unacknowledged assumptions or biases. In conclusion, a comparison between sources was made highlighting how each source relates to other work on the topic and if other work would support or dispute the reviewed work.

The final annotations identified the main arguments, insights, and key ideas. Subsequently, we decided to include the purpose of work, the audience, and the author's sources. This helped build a bridge between the works done and identify the reliability of the sources. These annotations were done to summarize the articles for later use and discussions in the project and ensure a profound comprehension and interaction with the topic. A final step was added after further discussion and analysis of the works. To expedite my research on roboethics and its applications, we began to identify the AI principles themes that apply to each work at the end of the annotations. This step allowed us to develop and evaluate assumptions and viewpoints formed upon different situations during an urgency.

3.1.2. Examining Robot Roles in the Fukushima Daiichi Nuclear Disaster and Analyzing Ethical Discussions Related to robots and AI Deployment

The same principle of the annotated bibliography was applied while investigating the Fukushima Daiichi disaster. This time, we began to explore an incident where - again - based on the public response, robots could not unravel an emergency. The following questions were asked:

1. How robots have (or have not) been responding to the nuclear disaster in Fukushima Daiichi and its effect on social life?
2. What are the ethical concerns related to the use of robots during the nuclear disaster?

Unlike the COVID-19 pandemic, a global crisis that nearly hit all nations, the Fukushima Daiichi disaster predominantly hit Japan's people, economy and industries. Therefore, it was not easy to track down reliable sources in databases other than Japan's. One possible tactic was searching through Japan's Google search engine. According to Plimmer (n.d.), users get varying results in Google based on location, personalization, and algorithm variations. Some of the articles found regarding the Fukushima disaster were translated from Japanese to other languages, including English, by the author. Other ones were written in Japanese and translated to English with the website auto translation feature. Because information's credibility was a major concern for my research, I disregarded the webpage translation option and only analyzed works written in English or translated by the author. Moreover, week by week, feedback from the project team was held to ensure staying on task and producing excellent understanding and analysis on the topic.

3.1.3. Comparing the Ethical Discussions Highlighted by Both Disasters

The final step of my research was to compare ethical discussions and analyzed data from both incidents. The following questions were considered in this step:

1. Was the technology able (or not able) to solve the disaster?
2. How different (or similar) were the public's ethical concerns to each incident?

Several discussions, driven by the annotated bibliography work, determined the answers to these questions. Additional obtained sources were dissected to support this project's claims and help achieve the project's objectives. The next section details the results of my research and provides detailed data analyses that helped in framing this project's conclusions.

4. Case Studies

The overall goal of this project was to investigate roboethics in terms of global disasters. To do so, the project examined two incidents: The novel coronavirus pandemic in 2020 and the Fukushima Daiichi nuclear disaster in 2011. The subsequent sections present a detailed case study of urgency roboethics applied in recent global examples.

4.1. Novel Coronavirus (COVID-19)

A new coronavirus in the form of acute pneumonia identified has caused a global disaster ("WHO releases guidelines," 2020). The virus first appeared in the Chinese city, Wuhan, at the end of December 2019. In January 2020, the Chinese government identified this new virus through genetic sequencing and announced that it is responsible for an increasing number of sick

Chinese citizens. A surge in the number of cases was recognized by international medical authorities, and WHO declared the outbreak a Public Health Emergency of International Concern on 30 January 2020. On 11 March, WHO declared the new coronavirus disease, abbreviated to COVID-19, a pandemic. The incubation period for COVID-19 ranges from one to fourteen days. About 80% of those who died were over the age of 60, and 75% of them had pre-existing health conditions such as diabetes, hypertension, heart or respiratory disease, and compromised immune systems ("People at increased risk," 2020). COVID-19 spreads primarily when people are in close contact, and therefore, as a step to mitigate the spread of the virus, the US Centers for Disease Control and Prevention (CDC) recommended 2 meters of social distancing. Large numbers of health workers have had to continuously work to save lives and make life-and-death decisions due to the limited medical supplies - creating the most prominent health crisis since the Spanish flu pandemic in 1918 (Gates, 2020).

The impact of the coronavirus outbreak in 2020 extends far beyond just a health crisis. According to the United Nations (UN) in *COVID-19 Socio-economic impact* (2020), the COVID-19 pandemic is far more than a health crisis: it is affecting societies and economies at their core. The UN called for even more urgent responses as the epidemic is most likely to increase inequality and poverty on a global scale. COVID-19 also affected cultures, religious rituals, supply chains, industries, and education. Cultures that stress family and community interaction on a daily or weekly basis cannot gather and spend time together due to social distancing. The enforced lockdowns led multiple individuals to commit suicide caused by a deterioration of their mental condition (*IANS*, 2020). In addition, after the city of Qom - a religious place in Iran - was harshly hit by the coronavirus, churches worldwide had to cancel their Sunday service, and temples closed their doors for the public in fear of spreading COVID-19 among their communities (Robinson, 2020). Prayers in Medina, Mecca, and Jerusalem, the three holiest places in Islam, known for their annual pilgrimage, were also suspended, and mosques worldwide had to close their doors (Adamczyk, 2020). Another impact of the coronavirus outbreak was the inventory shortages in food, medications, face masks, sanitizers, and, most importantly, ventilators. Ventilators were the only way to get the oxygen into the patients after their lungs fail due to COVID-19 complications. According to Akpan (2020), the US needs three hundred million respirators and face masks to protect health workers against the coronavirus threat; however, the nation's emergency stockpile had less than 15 percent of these supplies. The shortage in the medical supplies caused health workers to make 'gut-wrenching' choices on which patient gets the available ventilator. It caused many frontline health workers to die due to the limited protective gear equipment (Glenza, 2020). These impacts led to a global transition towards more technology usage and urged the necessary integration of robots and AI in health sectors to fight the pandemic. They also called for more funding support to emergency response robots and AI applications to avoid similar situations in future pandemics.

The term "social distancing" led to implications that people should practice complete social isolation; therefore, the WHO replaced the term "social distancing" with "physical distancing" in late March, emphasizing the importance of reduced physical contact in public spaces while still maintaining social practices through alternative solutions (Jones, 2020). Social distancing included travel restrictions, schools and universities closure, layoffs, and much more limitations imposed by governments. Also, many governments mandated self-quarantine for those who have recently traveled from a high-risk area for 14 days. All of these restrictions and implications made it more challenging for both the public to maintain daily practices and the government to manage the spread and impact of COVID-19. Hence, nations started utilizing technology - particularly robots and AI - to fight against the coronavirus outbreak and recover from the impacts of the virus. The next section details the roles robots and AI played during the COVID-19 pandemic.

4.1.1. Robots in the frontlines

When the COVID-19 outbreak hit, robots and AI became acknowledged as a necessity after these technologies presented hope to the public. A critical aspect of robots during the pandemic is that an increasing number of them can operate without relying on the physical presence of humans (Griffith and Metz, 2020). Therefore, in an era where everyone is required to social distance, robots came to save the day. Robots played a notable role in the current coronavirus outbreak despite rising concerns of AI and robots' implications. Nations worldwide began to innovate their technologies and derive the aid of industrial, surveillance, and interactive robots.

One way robots have been utilized in the current pandemic is surface cleaning. In Houston, Texas, and all the way to Rwanda, Africa, hotels, and medical centers used robots to disinfect surfaces with ultraviolet light in addition to the extreme cleaning up routines (Purtill, 2020). When a COVID-19 case is suspected or confirmed, all areas used by the infected individual should be disinfected. Surfaces may be decontaminated either with chemical disinfectants or with exposure to Ultraviolet germicidal irradiation (Glusac, 2020). The chemical solutions proved to be impractical as it usually takes more than 5 hours to disinfect a room thoroughly. It is also not possible to use this approach in many of the hospital rooms, such as rooms occupied by patients. Ultraviolet light, on the other hand, has been proven to be powerful enough to kill viruses; therefore, a team of researchers worked on the idea of developing a disinfecting robot long before the coronavirus outbreak. When the pandemic hit, and the first Ireland case was confirmed, the Irish team of researchers came together to develop a robot that navigates independently, senses a human presence and stops when presence is detected. Since the process of disinfecting surfaces takes a long time, Akara Robotics, a robotics and AI company, developed a new robot named Violet to help disinfect contaminated surfaces during the COVID-19 pandemic (Purtill, 2020). Akara Robotics designed Violet to be compatible and light as possible to allow its use in crowded and narrow places. Violet was initially intended to be Stevie, an interactive robot that alleviates loneliness. However, when the coronavirus hit, the company equipped Stevie with a UV-C light as the world healthcare system was looking for possible ways of aid. Violet is one of the many robots deployed on the front lines of the global disaster.

Another example of robots deployed during the coronavirus outbreak to assist health workers and patients is Boston Dynamics' customized robot - Spot. Spot, a four-legged robot, has been deployed to help health workers in Boston's Brigham and Women's Hospital (Slotkin, 2020). One advantage of using a legged robot is increased mobility compared to drones or wheeled robots. Spot was not developed for a medical purpose, but it has been utilized to work along with health workers during the pandemic. Since robots do not have a risk of getting infected by diseases and could be efficiently disinfected with chemicals, they could potentially play a vital supporting role next to health workers in future outbreaks. Hospitals in the US and across many countries used robots to take temperatures, measure blood pressure and oxygen levels, and deliver food and prescriptions to quarantined patients. Hence, it could be said that investing in robotics research laboratories nowadays would prove its worth in future health emergencies.

A pattern of redesigning already existing robots to help during the pandemic was observed in the process of this project's investigation. Violet and Spot are both robots repurposed during the coronavirus crisis. But why is it that many of the deployed robots are the ones already designed and have been redeveloped during the pandemic to work along with health workers?. One problem for not having fully equipped robots during an emergency is the fact that the best time to test emergency responding robots is during an actual outbreak (Khan, 2020). For doctors, they are already dealing with high-stress and high-risk situations; they do not have the time to figure out how robots in their working environment function. Guang-Zhong Yang, dean of the Institute of Medical Robotics at Shanghai Jiao Tong University, said: "You can't just design a robot and take it to a hospital and say, 'Here, use my robot.'" Incorporating something new during the time of a crisis could lead to something wrong happening that could cause the death of some people. Therefore, it is essential to start integrating robots in hospitals during real-life situations and periods so that when an emergency hits, health workers are at least used to having those robots around and will be able to utilize them in their best interest. Likewise, this will make it easier for engineers to predict and redevelop the deployed robots for specific tasks in future outbreaks.

An example of an application developed during the COVID-19 pandemic and failed to be used is Pal Robotics' ARI robot. Pal Robotics, a robotics company, began developing an

Artificial Robot Intelligence (ARI) robot model in the light of the COVID-19 pandemic. The company utilized ARI to provide patients a personalized experience and assist health workers with essential tasks during the pandemic, such as welcoming newcomers, helping with check-in forms, and other guided tasks (Hampson, 2020). Though ARI applications would have proven useful in assisting health workers during the coronavirus outbreak, the only setback for the model is that it was designed concurrently with the outbreak. The surge in hospital cases has prevented proper testing of the model, as Francesco Ferro stated, CEO of PAL Robotics. As of April, he stated that their work was still pending due to the enforced lockdown (Khan, 2020). This reinforced the notion that the best robots used during an emergency are already in use before the disaster (Adams et al., 2020).

Robots have also saved the supply chain during the pandemic. Companies and industries began to leverage robots instead of human workers to lower the risk of infection and avoid shortages in the supply chain. For example, Denmark invested in automated slaughterhouses, which in return forestalled a COVID-19 hot spot inside the nation and continued the country's production of meat. However, numbers of US plants for meat production have paused operations after workers tested positive for COVID-19. Slaughterhouses are among the many sectors hardly hit by the virus in the US (Molteni, 2020). As of April 2020, according to the New *York Times*, the food supply chain in the US is breaking. The period in which slaughterhouses in the US had paused has impacted and will continue to impact consumers in the long run as meat prices have increased (Law, 2020). While it is true that some workers can be replaced with robots, the lives of many people might be saved.

These are only a couple of the numerous ways robots were used to help carry out day by day public work and life and support public safety and healthcare. Regardless of whether it was the compulsory move to automate many work policies or the enormous accentuation on developing an advanced networking infrastructure, the world is witnessing what could be an AI revolution. The coronavirus outbreak may play a role in the acceptance and integration of technologies in societies and daily life. It may also speed the process of developing and adapting drone technology, just like World War II increased the development of many technologies. As per Williams (2020), on the future of drones, not only will drones be viewed as helpers, but perhaps even as "companions." Unmuted Aerial Vehicles (UAVs), also known as drones, have also been utilized during the coronavirus outbreak. The government of China, as well as many other governments, used drones to force the rules of social distancing, watch for any stay-at-home restriction violations, sanitize roads and public places, and carry test samples to labs (Morelli, 2020). In Silicon Valley and the UK, drones were used to deliver food and groceries. People in New York and across Europe used drones to walk their dogs and go out on dates during lockdowns (Williams, 2020). The co-founder of Azur Drones, a European leader in surveillance UAVs, argues that drones' use has revolutionized surveillance activities during the global coronavirus outbreak.

AI played a significant role in each stage of the pandemic. When the virus first appeared in Wuhan, China, BlueDot - a Canadian health surveillance AI software - discovered a cluster of unusual pneumonia cases and predicted where it could go next (Mazhukhina, 2020). AI software also helped limit interactions, map infections, model COVID-19 infected cells, analyze test samples, identify positive cases for the virus through X-rays and CT scans, and look through thousands of databases for a potential cure.

Despite the vast array of assistance AI provided, it also raised ethical concerns amid the pandemic. Job losses due to automation caused a spark in the roboethics world, and many people have been advocating against it. The biggest fear of robots and AI replacing human workers has immediately come true amid the outbreak. AI has also ignited privacy concerns as governments track locations and collect data to track the spread of the virus. The next section presents detailed findings on the ethical concerns during the COVID-19 pandemic in terms of the themes of AI principles.

4.1.2. AI Principles in the Age of COVID-19

The COVID-19 pandemic triggered the use of AI and robotic applications. It has also caused large businesses closure and job losses due to lockdowns and social distancing guidelines. Urgent AI and robotic responses were required when the pandemic hit, causing many governments and industries to implement AI frameworks without overlooking its risks (Greenman, 2020). The public was divided in their point of view. Some questioned whether it is worth implementing AI into the health, surveillance, and industrial fields, and if sectors should wait until all ethical questions about AI are resolved. Others were urging for faster deployment of robots and AI to assist and help carry on daily life practices while acknowledging the ethical concerns of their uses. Either way, both parties would have agreed that with transparency in action and laws that reserve the public's safety, security, and privacy, many ethical issues raised during the outbreak would not have existed. Therefore, AI utilization became a conflicting matter of balancing the need to protect the public against AI ethical concerns with the need to stop the virus.

4.1.2.1. Privacy

Health sectors, governments, and industries are constantly working to find solutions to the ongoing pandemic. The governments' and organizations' presented solutions raised ethical concerns in public. Some people were willing to forgo their privacy to avoid the risk of virus infection and fight the pandemic. Others were not willing to, even if it led to them getting infected. Contact tracing is a textbook example of the last. Contact tracing is a technology hugely dreaded by the public in light of the pandemic. Governments worldwide utilized contact tracing technologies to combat the spread of COVID-19. According to Greenman (2020), AI has become a crucial weapon in tracking and tracing cases. For instance, Russia has been monitoring citizens for quarantine violations through facial recognition technology and CCTV cameras. China has also been using AI-empowered drones to identify people who are not wearing a mask or with a high fever. These technologies have also been detecting movements and gatherings that do not follow social distancing recommendations.

In May 2020, Google and Apple rolled out an exposure notification application programming interface (API) to allow health agencies and governments to notify people through smartphone notification or text that they have come in contact with someone tested positive for COVID-19. Google and Apple collaboration to build high-tech Bluetooth-based technology to track coronavirus cases. In their move to aid in the fight against the coronavirus pandemic, the two companies stated that the smartphone app's goal is to prevent the spread of the virus. In the companies' defense, these contact tracing apps only work when people indicate that they have tested positive for the virus, and API does not track locations otherwise (Brandom and Robertson, 2020). The companies explained that the technology uses Bluetooth to keep a record of others' devices and notify users that have been around someone tested positive for COVID-19 for more than fifteen minutes and within six feet of distance. However, Google and Apple have long been known for their privacy invasion and data collection practices. Therefore, many countries refused to utilize the newly developed technology due to the lack of trust because of previous violations (Browne, 2020).

In another example of AI privacy violation amid the pandemic, the utilization of drones to combat COVID-19. In many countries, security forces relaxed the rules on the use of drones and extended the operating perimeters. The US government used drones to scan for body temperatures and disperse gatherings (Pressgrove, 2020). Many people in the US fear drones as they are viewed to be invading one's privacy when they fly over houses to capture footage and collect data. Surveillance and police stations reassured people of their privacy concerns during the implementation of the UAVs to fight the outbreak. Still, some people were not ready to trust the new technology and accept it as part of the new style of life. For instance, citizens in Colorado proposed an ordinance allowing them to shoot drones flying in the sky (Williams, 2020). Societal acceptance of UAVs depends strongly on age, country, and culture (Morelli, 2020). It also depends on the trust governments and companies build with ordinary people.

These privacy concerns in terms of data collection have proliferated since the pandemic started. The data collection process not only collects information on a person's COVID-19 diagnosis or location but also looks through the person's past health records, real names, national

ID numbers, phone numbers, home addresses, bank information, their faces, fingerprints, and much more. Nobody wants to be scrutinized by the government, nor by companies and organizations. A leak in people's collected personal information ending up in the wrong hands could cause many problems. As a recent example, China's broad data leak amid the coronavirus pandemic. Data collection was the local government's and organizations' default method to combat the spread of COVID-19. People who complied with the government and provided their personal information to fight the pandemic in China were struck when they saw their information circulated around WeChat, a Chinese social media app, groups in spreadsheets (Shen, 2020). Following the data leak, online harassment, spam calls, threats, discrimination, and a lot more. According to Shen, "Chinese media reports show that personal information leaks from anti-epidemic efforts are happening on a large scale in China. And in some cases, those in charge of the data are the ones leaking it." This, in turn, led people to question whether their information is being well protected.

Aggressive data collection practices that evoke privacy violations took place amid the pandemic. Acknowledging that this information might as well stay after the pandemic ends, raises ethical concerns. People who complied with the data collection process to fight the pandemic might not have been aware that the giant databases built to trace the virus could potentially be used by organizations and the government even after the world breaks free of COVID-19. A critical question to ask is once surveillance databases are established, how could that power be removed from governments, companies, and others? (Borenstein & Howard, 2020). The world is still working to fight the ongoing pandemic; nevertheless, it is worth asking what comes after the pandemic? It is essential to mitigate the spread of COVID-19 to save individuals' lives, but it is also important to implement privacy restrictions and protection plans on collected data to prevent data abuse in the future. Organizations could find it tempting to keep people's data to attract consumers and make a financial profit when the pandemic ends; hence, it is crucial to rethink the harmful consequences following the crisis. To preserve the public's cooperation and trust in AI frameworks, governments and organizations must implement ethical AI governance architecture and leverage the best AI applications for the current situation without exploiting the public's data. As Stuart Hargreaves, a law professor at the Chinese University of Hong Kong, said, "All societies must grapple with how to balance public health interests with personal privacy rights" (Shen, 2020).

4.1.2.2. Safety and Security

AI has emerged as a formidable tool in detecting and predicting outbreaks as the globe continues to deal with the unprecedented circumstances due to the coronavirus pandemic. AI proved to be a step ahead of humans in many tasks during the outbreak, including tracing COVID-19. According to Wood (2020), the AI systems utilized in tracking the virus are automated on data mining and incorporate trained machine learning algorithms to spot patterns in large-scale data sets. Amid the coronavirus outbreak, governments and companies implemented AI surveillance tools for public places, such as thermal imaging cameras, facial recognition cameras, or CCTV cameras, to capture those not wearing masks and social distancing violations. In Russia, facial recognition technology was used to catch those violating the quarantine requirements (Greenman, 2020). Such a powerful tool to detect and track the public presented promising yet concerning advancement. AI systems were also utilized to identify early signs of the outbreak by aggregating government websites, social media platforms, and news reports (Wood, 2020). The early detection of the virus helped many nations, such as Taiwan, prepare for what was coming after the WHO declared an international emergency (Bremmer, 2020). The country quickly shut its borders and implemented the use of masks and social distancing regulations. As of June 2020, Taiwan registered seven deaths for 443 cases of COVID-19 in total. The government used mobile Sim-tracking and contact tracing software to identify and ensure those in quarantine are abiding by the rules. It is clear how AI helped ensure safety and security in public places during the pandemic; nevertheless, it has also trespassed many ethical principles.

The increased trust in technology during a global emergency presents future security threats. The social-ethical concerns introduced by the accelerated implementation of AI during the coronavirus crisis could lead to another potential security disaster. Many of the articles and journals investigated for this project warned on the ramifications of significant reliance on automation. Strong regulations to limit the usage of collected data by organizations during the coronavirus outbreak should be applied to ensure the public's safety and security, and secure ethical usage of data. Contact tracing technologies and apps present a threat to people's safety as their location is continuously monitored. It also presents a danger to surveillance security since every move is detected, and critical information, such as bank information, are all recorded. If one person from either of these organizations collecting information misused the data, it would impact those whose information has been abused and organizations long-term. The precedent pandemic's challenge is that the short-term measures to assess public health risks personal data safety and security in the long term. In the US, tracking applications, and tools that help screen employees and monitor social distancing might not be covered adequately by the sector-specific federal framework (Wood, 2020). Thus, it raises questions about whether a private entity or the government is holding the collected data.

In an opposing argument regarding the COVID-19 AI early detection, AI software might have only sounded the alarms for a potential virus, but human analysis grasped the coronavirus outbreak (Engler, 2020). As per Alex Engler, a David M. Rubenstein Fellow in Governance Studies at the Brookings Institution, machine learning depends on historical data to create meaningful insights. Since there was no database of previous Covid-19 outbreaks when the virus was first detected, AI could not have predicted the spread by itself. Moreover, Engler describes AI's ability to predict emergency events as a claim that overstates AI's actual capabilities. AI could be used during a crisis to mitigate the widespread impacts and assist in carrying out challenging tasks to humans at a quick period. Still, it might not yet be fully developed to help prevent and predict a future crisis happening. On the other hand, David Feinberg - the vice president of Google Health - stated that contact tracing API software that fuels AI services can be a more efficient way to track down and reach out to the public (Lndi, 2020). The difference here is that Engler supports leveraging AI in the best ways to help during an emergency without violating ethical practices. At the same time, Google pushes to break many ethical guidelines by only carrying on with its goals. As Elon Musk once said, "AI doesn't have to be evil to destroy humanity – if AI has a goal and humanity just happens in the way, it will destroy humanity as a matter of course without even thinking about it, no hard feelings" (Asakawa & Deeter, 2018, 0:45:13). AI might not have destroyed humanity during the COVI-19 pandemic; however, it has destroyed many of the public's privacy and safety by creating these massive databases of personal information to contact trace the virus without putting time limitations and reliable protection. Musk's saying supports many organizations' ignorance of ethical concerns towards developing a short-time solution to an emergency, which could be seen in the ongoing pandemic. According to Borenstein & Howard, if AI and robot threats are not addressed and quickly solved, a crisis of another form may be looming after the pandemic ends.

4.1.2.3. Fairness and Non-discrimination

"If you want the bias out, get the algorithms in," said Andrew McAfee, a research scientist at MIT. AI bias has been a heated debate in the world of roboethics for many years. According to Howard and Borenstein (2020), the public overlooks the former uneasiness about robots and AI as the technology's perceived value outweighed its anticipated downsides. In the light of the coronavirus pandemic, a group of people shed light on the importance of using AI to mitigate the effects during the outbreak; however, the other group of people concentrated on the aftermath of existing AI applications when the pandemic comes to an end. Bias in AI exists, and it is a concern that could lead to life and death ramifications. Knowing that AI has biases, it shakes the public's trust in technologies. Facial recognition technology, a widely utilized software in the COVID-19 era, has been proven to have race and gender bias (Ivanova, 2020). Roboticists and engineers have been working to implement AI into deployed robots in the ongoing pandemic to assist health workers and law enforcement agencies. There is not any comprehensive analysis of biases in COVID-19 treatment and surveillance algorithms yet, but, as we have seen with many previous situations, it is very likely that gender, racial and other biases still play a role.

AI has been leveraged during the ongoing pandemic to reduce the strain on the overwhelmed health workers. There has been a challenge in balancing the benefits of implementing AI during the health crisis and its robustness and safety risks. The extensive implementation of AI in a short time period has highlighted ethical concerns and considerations regarding AI's bias in the healthcare sector. In 2019, researchers at UC Berkeley published a shocking study revealing an algorithm widely used by many US health organizations to predict which patients need extra medical care was biased against Black patients (Dickson, 2020). The algorithm, later identified by Washington Post as Optum, used to bump up the queue and privilege white patients over black patients for specialized treatments of complex conditions like diabetes and kidney problems. The researchers looked over almost 50,000 records at a hospital and found that Optum's AI algorithms gave white patients higher risk scores, which were then selected for extra care, than equally sick black patients (Jee, 2019). The healthcare company, Optum, was found to apply its algorithms to an estimated 150 to 200 million people. The way the algorithm worked was it predicted how much patients were likely to cost the healthcare system by looking at their medical histories. As discussed in the background section (see 2.3.4.), black patients admitted to healthcare in the US received cheaper and older treatments than their white counterparts (Bridges, n.d.). Therefore, the socioeconomic result of discriminating against black patients led the algorithms to score white patients in need of extra care higher than black patients who were significantly sicker. This is one of the several algorithmic biases examples of AI's tendency to make unfair decisions in the healthcare field against a particular racial group or gender. .

The COVID-19 pandemic sparked another debate on AI bias in health care applications.The world is leaning further on the implementation of AI decision-making systems during the outbreak. More AI systems are being developed to help during the pandemic as well as after it ends. Potential AI databases could handle cases where decisions of who gets the last existing ventilator might lead to undesired consequences (Borenstein & Howard, 2020). Therefore, it is essential to reconsider the biases AI and robots adapt by interacting with humans before relying more on these technologies. In addition to the health crisis COVID-19 caused, it might also have started an automation crisis. Many people have lost their jobs due to the enforced lockdowns or fear of contracting the coronavirus. For instance, many essential workers, such as mechanics, dealers, and perhaps even orthodontists, were impacted by the pandemic as they lost consumers, buyers, and patients. The COVID-19 impact on jobs raised many warning signs for another kind of a potential disaster after the pandemic ends. Biases do exist in hiring fields; therefore, to eliminate humans unconscious bias when hiring applicants, AI has been utilized in recruiting. However, AI itself presented bias against applicants. In 2015, Amazon's machine-learning specialists uncovered a significant underlying problem; the new recruiting engine was found to discriminate against women (Dastin, 2018). The AI model was trained by observing patterns of submitted resumes to the company for over ten years. Due to the gender inequality present in the US occupation sector, most of those who submitted were men. Therefore, in an unprecedented step by AI, the bias found in the real world was implemented into the system. Amazon's system was not rating candidates for software developer positions or other technical positions in a gender-neutral way. The male dominance in the technology industry was reflected in the trained system initially developed to eliminate human bias.

COVID-19 expedited the usage of AI systems to overcome problems on a short-term basis. Therefore, in a step to combat the vast numbers of unemployment rates due to automation and social distancing requirements, recruiters might start implementing AI recruiting systems into the frameworks to ensure a faster-recruiting process to overcome the impacts of the pandemic on them. This short-time response to the disaster, in return, presents another disaster over the long-term. These biases could expand societal inequities and pose a bigger society and economic risks. These inequities presented in societal and income standings could then further expand AI's biases in either the medical or recruiting fields, resulting in a loop of AI's unfairness and discrimination.

In a recent scholarly article published by the Stanford Center on Philanthropy and Civil Society at Stanford University, AI systems utilized the coronavirus pandemic were found to have Rustagi biases. According to Rustagi and Smith (2020), much of the data the CDC and other US organizations collecting about COVID-19 are biased and incomplete. The collected medical data mainly reflect the affluent white communities who had access to limited tests, and only a subsequent part of the rest of the population is reflected. For instance, COVID-19 contact tracing systems have not been collecting data on immigrants or marginalized populations. Transgender and non-binary individuals have also been under increased risk of medical bias after the Trump administration enabled health care discrimination against LGBTQ people (Urquhart, 2020). This move prevented many patients who identify as LGBTQ and transgender, not to include their medical history and sufficient data. The lack of data on this marginalized population impacted AI systems and will perhaps continue to impact it further if not quickly solved. Another form of AI bias in the age of COVID-19 is the lack of collected data on racial and ethnic groups and gender (Rustagi & Smith, 2020). The CDC was found to release incomplete and infrequent data on black Americans, which increases the gap in AI biases embedded in AI systems more than ever. In another case of AI bias in the CDC systems, much of the data shared by hospitals and states are broken down on race, ignoring patients' gender. The absence of sex-disaggregated mortality data presents another risk of AI bias in future settings.

Similar to medical AI framework considerations, surveillance tools also carry a lot of ethical implications. Contact tracing apps that use facial recognition enforced lockdowns and social distancing guidelines in public places. In order to mitigate the spread of COVID-19 after lifting enforced lockdowns, China utilized a system of scoring individuals to determine who gets access to public destinations (Li, 2020). Using AI to decide who gets to leave their homes will present biases against marginalized populations as biases have been proved to exist in surveillance tools. If this AI framework were to be implemented in the US, women, minorities, transgender, LGBTQ, immigrants, people of color and poor communities would be hard hit by the administered systems due to historical discrimination and inequities. The ongoing outbreak probes the public's fears in many ways; one way it does is through the unfairness and discrimination embedded into AI systems. If an AI database started to decide who needs to get the ventilator from a pool of patients, the value of the life of individuals facing inequality in socio-economy and medical care would be compromised. Therefore, it is crucial to start fixing the biases in AI systems before further implementing these technologies. AI bias could manifest in any field, but in the healthcare field, it could be deadly. Trying to develop race-blind software will most likely not solve the discrimination problem. "While developers aim to make algorithms race-blind by excluding race as a metric, this can ignore or hide— rather than prevent—discrimination," said Rustagi & Smith in *The problem with COVID-19 artificial intelligence solutions* (2020). Enacting robust plans to protect the public's safety, privacy, and security against AI's ethical considerations would help develop frameworks more secure and less biased. It could also help protect the socio-economic standings of minorities and the poor.

4.1.2.4. Transparency and Explainability

Amid the COVID-19 pandemic, the whole world relied on technologies to overcome the challenges presented by the health disaster. Robots and machines helped the public stay in contact with each other while minimizing close in-person interactions, while AI systems helped the governments to trace the spread control hotspots of the virus. The massive surveillance move of collecting data with no imposed regulations and limitations caused a lot of fear and confrontation among the public. Perhaps, what has also fueled the public's fear during the pandemic was the lack of transparency and explainability from governmental and industrial sectors.

Many AI algorithms and their applications are not transparent. The lack of transparency in data manifested odd behaviors amid the COVID-19 announcement. For example, after WHO declared COVID-19 a pandemic, people in the US were panicking and buying toilet papers from stores and grocery store shelves ran empty, and supply chains were impacted. As the uncertainty of such situations causes people to panic, transparency is a crucial component of any strategy that aims to avoid disasters of other kinds. On March 30, the WHO emphasized the need for "frequent transparent communications with the public, and strong community engagements so the public can maintain trust in the system to safely meet their essential needs and to control infection risk in health facilities" ("WHO releases guidelines to help," 2020). Transparency and explainability of AI systems in global disasters help fix existing framework issues. For instance, algorithmic biases usually vet through specific information to learn on a particular subject matter. These machine-learning algorithms might then pick up hidden biases presented in forms of socio-economic, gender, or racial inequity and become damaging. It is difficult to pick up on these data points, which is why transparency in AI algorithms would help identify and, therefore, lessen the bias. In an example given by Dickinson, skin-cancer-detection algorithms might eventually develop biases in an unpredicted roll. These algorithms are trained on images of malignant moles and healthy skin. Photos for skin cancer cases usually contain rulers to depict the size of the mole; hence, the trained AI system might become biased toward detecting rulers instead of malignant moles (Dickinson, 2020).

In addition, transparency in action and collected data in contact tracing apps might help reduce the resistance to comply with governments' implemented AI tools in many places. The future of the data collected by contact tracing apps developed by organizations is unclear. In the ongoing pandemic, these data serve to help locate and enforce lockdowns to save the lives of the most vulnerable. However, when the pandemic ends, these data would serve as a financial profit to many organizations and hackers. Some companies might refuse to remove the collected data from their databases, ultimately. Due to the lack of transparency between the organizations and the public, there is no way to ensure the data's ethical usage. On another note, if not protected well, many of the public's personal information will circulate around imposing higher risks of online threat and abuse. Therefore, companies and governments must explain and become transparent with the rest of the world in order to win their trust. Else, just like Apple's and Google's contact tracing API application developed to protect individuals from contracting the virus, countries, and people might not trust the product due to the lack of transparency. In turn, this presents financial loss to these organizations and a lack of trust in technologies deployed in future disasters.

4.1.3. Lessons Learned

Disasters present a unique opportunity for the world to learn from its experience, perhaps the COVID-19 pandemic did so too. The coronavirus outbreak in 2020 could become the catalyst for the development of medical and surveillance emergency response robots. Everyone during the pandemic was trying to do something to help. Companies started to 3D print masks and ventilators to cover the supply shortage in the world. Others repurposed their robots and equipped them with the necessary tools to assist health workers or carry out tasks that require human interaction. Japan, for example, has utilized robots to replace its students in graduation ceremonies amid the coronavirus outbreak (Gallagher, 2020). One of the main lessons reiterated in many of this project's sources is the fact that the best robots during the pandemic, are the ones already in use. According to Adams et al (2020), repurposing existing robots is generally more effective than building specialized prototypes since building a new, specialized robot takes years. Another lesson from this global health disaster is that robots do not replace humans. Social distancing guidelines did lead to the loss of many jobs, but robots have not entirely replaced human workers, take for instance health workers. The doctor-patient interaction is important and developing medical robots is challenging as robots lack one of the critical factors in the medical field, empathy. Robots also carry out few concerning ethical actions embedded into them through humans, such as unfairness and discrimaniation presented in many AI systems. Hence, robots will not be replacing human interaction but instead channeling it (Simon, 2020). Another challenge for engineers in developing fully autonomous medical response robots is the fact that robots need to balance functionality with the patient's psychological needs. Perhaps setting up robotics challenges in hospitals for engineers in a time of no crisis could ensure having some more equipped robots fighting in the front lines when the next global health disaster hits.

COVID-19 also shed light on many of the ethical issues related to AI systems. Contact tracing, a technical method established by governments and organizations to mitigate the spread of the virus, imposes a lot of risk to what comes after the pandemic ends. Another lesson learned in the ongoing disaster is the importance of transparency and explainability of implemented AI systems. This is important such that it ensures less bias in the AI databases and prevents organizations abuse of the public's collected personal information. The huge databases created to prevent further spread of the infection need to be regulated, else COVID-19 contact tracing apps will continue to jeopardize the lives and livelihoods of various nations around the globe even after it comes to an end. These regulations might include imposing time and utilization limits to ensure ethical usage of collected data, fairness and inclusiveness, and transparency. The personal data should be restricted to be viewed by specific individuals to guarantee the enough protection of the collected data. Also, there should be a time set to use these data such as until the end of this pandemic, and after the duration ends all data should be deleted. Finally, transparency of the data being utilized and the purpose of their usage should be communicated to the public. All of these steps help build trust in governments and companies, and prevent a looming disaster of another kind to take place after the current pandemic ends.

4.2. Fukushima Daiichi Nuclear Disaster

The impacts of the Fukushima Daiichi nuclear disaster in 2011 could still be seen today. On March 11, 2011, a strong earthquake hit the northeast coast of Japan, causing the worst nuclear disaster in history (Cheng, 2019). The earthquake moved Japan's coast by 8 feet and shifted the earth's axis by 4 inches. Following the earthquake, a 15 meters tsunami disabled the cooling and power supply of three of Fukushima's nuclear power plants, causing the cores of the reactors to melt in three days. Hundreds of fuel rods went missing inside the three reactors that suffered core meltdowns, and Tokyo ordered a 12 miles radius exclusion zone around the plantume (McNeill, 2011). Residents, estimated about 83,000, had to evacuate the towns around the nuclear plant due to the high radiation levels in the area and up until this day, they are waiting to get back to their homes (Fackler, 2013). The radiation levels have also contaminated water and food supplies in the area, and in August 2013, Japanese officials announced leakage of highly radioactive water into the pacific ocean. An estimated 320,000 gallons of radioactive water was released into the ocean, causing a new type of a crisis - this time, an environmental disaster (Schauenberg, 2020). As a step to mitigate further nuclear meltdowns, the contaminated water has been used to clean up the reactors and then stored in large closed tanks. However, the tanks were estimated to fill up by 2022, forcing Japan to dump the contaminated water into the pacific again (McCurry, 2019). Water that escaped Japan reached the western coast of North America by 2014, but researchers said that it posed no threat to human health since the contamination level was too low (Sherwood, 2014).

Japan faced a significant problem in tracking the radioactive release due to the harmful radiation levels emitted from the power plant reactors. According to Cheng, in a recent visit to the Fukushima area in 2019, radiation 60 feet under the ground was emitted at 1 sievert per hour, enough to cause radiation sickness. According to *The Guardian* (n.d.), exposure to a dose of 5 sieverts per hour would kill half of those exposed to the radiation dose within one month, while exposure to 10 sieverts per hour would be fatal within weeks. When the Fukushima nuclear disaster occurred in 2011, locals and people worldwide dreaded another radiation crisis similar to the Chernobyl disaster in 1986. Fukushima's plant caused zero deaths by the time of its explosion; however, it caused an environmental and a health disaster. According to Weisberger (2019), the extent of Fukushima's environmental impact is still unknown. Genetic mutations on butterflies were found in a study of the Fukushima area (Oskin, 2012). Butterflies within the radiation area developed deformations in their eyes, wings, and legs. Timothy Mousseau, a biology professor at the University of South Carolina studying the impacts of radiation from Fukushima and Chernobyl explosion, said: "One very important implication of this study is that it demonstrates that harmful mutations can be passed from one generation to the next, and that these might actually accumulate and increase over time, leading to larger effects with each generation." In 2018, the California Department of Public Health declared wines produced in California were not dangerous to consume after experts detected elevated levels of radioactive cesium-137, an isotope produced only through atom bombs, in wine productions (Grennell, 2018). Even though detected levels of radiation on the western coast of North America and California's wine were said to be harmless for the time being, impacts of little by little consumption of cesium-137 will be seen in the future.

Fukushima's nuclear disaster also impacted Japan's energy industry as well as the world's nuclear industry. Japan's government estimated the cost of repairing Fukushima as 75.7 billion dollars (Cheng, 2019). The estimated cost nearly tripled to 188 billion dollars in December 2016 (Beiser, 2018). It also estimated the time it would take to fully decommission and dismantle the nuclear platinum to be 40 years. The disaster forced Japan to shut down some of its nuclear power plants, and the industry lost much of its public support. Following the disaster, two of Japan's prime ministers opposed and called to eliminate nuclear plants, which also impacted the global nuclear industry. Countries such as Germany put down their plans to build nuclear power plants and phased out even commissioned power plants (Arlt & Wolling, 2015). These long-term global impacts all prompted the deployment of emergency responding robots to help clean up the area. It shed light on the importance of developing emergency-response robots for future disasters. Since restoring missing rods in a highly radioactive environment presents an enormous risk to human lives, robots were declared the initial solution to Fukushima's disaster. Many robots were designed to speed up the process of cleaning up Fukushima and locate the missing fuels. The following sections discuss robot applications deployed in the wake of the nuclear disaster.

4.2.1. Robots to the Rescue

Eight years have passed since the earthquake sent three of Fukushima's nuclear power plant reactors to an extreme meltdown. According to Beiser (2018), no amount of technology could fix the Fukushima disaster; instead, it will be a slow, intimidating process that must be carried out by robots. Human workers equipped with extensive protective gear could only reach a few spots inside the reactors due to the radiation levels; therefore, robots came to the rescue. Those working in the nuclear disaster area wear three gloves, two latex and one cloth, two layers of socks, bright heavy rubber boots, a white Tyvek suit, a bright yellow hard hat, a face clear plastic shield, and a full-face respirator mask (Cheng, 2019). Too challenging for humans to go inside the heart of the reactor to find the missing fuels, robots took on the mission to begin the clean-up process. For the past years, several robots were sent into the reactors to locate and retrieve the rods. The search for these fuel rods began as soon as companies like TEPCO started designing "shape-changing disaster exploration" robots (Ackerman, 2015). In 2011, one of TEPCO's first sent PackBots got stuck while exploring the Fukushima site after the disaster. The operation got dismissed, and the robot remains unretrieved; however, the robot succeeded in getting into hard-to-reach areas. It sent back useful videos and pictures as well as temperature measurements and radiation levels information before it got stuck. The data collected helped TEPCO carry out more exploration missions.

TEPCO's first mission was followed by a series of successful and unsuccessful attempts by many other industries. Robots usually ended up either tripping over the debris or losing wireless signals due to the thick walls inside the reactors. Also, in many robots, radiation fried up equipped cameras, microprocessors, scanners, and sensors. Robots that were lucky enough to overcome the obstacles and survive the radiation levels were immediately put away once on the surface again to prevent any radioactive contamination. In 2018, Kenji Matsuzaki - a senior scientist with Toshiba's nuclear technology branch - administered a mission carried by a robot nicknamed the Little Sunfish (Beiser, 2018). The robot initially had trouble with the connection; nonetheless, it was able to locate the first signs of the missing rods, seven years after the disaster.

As Lake Barrett, a consultant to Tepco, said, "It was a step, not a leap. We are getting closer and closer, but we have a long, long way to go." Barrett's saying reiterates one of this project's findings: the best time to test emergency response robots is during a crisis. This is the main reason why robust emergency robots are not immediately ready when a crisis hits. Despite Japan's advancement in robotics, Fukushima's challenging and unpredicted setting made it even difficult for robots to come for rescue.

4.2.1.1. A Sliver of Hope to Fukushima Residents

Unlike the multiple issues I analyzed with respect to the COVID-19 disaster, the range of ethical issues that emerged from the Fukushima Daiichi disaster was limited and primarily born out of the lack of transparency.The nuclear incident mainly affected residents from surrounding areas and the nuclear industries. It did not require continuous monitoring of the Japanese people and unlimited access to people's personal information. It also did not impose any massive surveillance actions or, by any proven way, present a threat to human lives due to embedded biases in AI applications. However, it did raise ethical questions regarding the transparency of Japan's attempts to recover Fukushima and the credibility of global nuclear industries. Some have argued that Japan's government is trying to convince the world that the situation was under control to avoid criticism. According to Yoann & Thierry (2014), TEPCO has been denying its lack of preparedness and escaping its responsibility by stating that an unpredictable tsunami caused the nuclear disaster. In turn, this led the public to question whether their lives are held accountable when agencies begin working on nuclear projects? It also led the nuclear industries, whenever a nuclear project is proposed, to question how to make sure this will not be another

Fukushima? The nuclear disaster prompted the implementation of more advanced robots and AI systems. Recruiting and adapting technology designs through competitions has long been known as an effective way to find solutions to rising real-world problems. The US Defense Advanced Research Project Agency (DARPA) competitions played a critical role in addressing the need to design emergency response robots for disasters. As per Greenemeier (2015), DARPA's annual challenge "gives roboticists an incentive to keep moving in that direction." Although Fukushima Daiichi's nuclear disaster was categorized as one of the worst disasters globally, DARPA claims that it has been "a great inspiration" in prompting the development of robotic first responders.

Robots and similar competitions offered some hope to the people of Fukushima amid the nuclear disaster - perhaps, maybe until recently. Years after hope and longing to return quickly, an estimated 50,000 Fukushima residents might have finally started to adapt to their new lives away from their home and accept that they might not be able to get back to their normal lives (Beiser, 2018). International organizations and fundings from the Japanese government rushed to help recover Fukushima. In the beginning, robots offered hope to residents of the Fukushima area; however, after a while, they were forced to accept the hard truth - it will cost a big chunk of robots and tools in addition to many years until the area stops radiating. According to Kolodny (2017), if TEPCO's energy and the Japanese government's funding were redirected to science fields, such as biology and chemistry, and efforts were further put into creating a shield around Fukushima, such as in Chernobyl, it might have solved the ongoing radiation disaster. Likewise, Kolodny suggests changing the approach to the efforts of the currently implemented solution. Perhaps, trust in AI systems is what the world awaits to finally locate and remove all of the missing fuels and speed up cleaning impacted areas. So far, all the robots deployed were remotely operated by humans. These AI systems could be taught by looking at records of attempted trials and other necessary information and then They could then be added to the deployed robots and monitored to see if they would tackle obstacles and find the missing fuels.

Later, Japan's Atomic Energy Center built a research center to simulate the environment inside the nuclear reactors ("*Innovation from destruction,*" 2020). The center contains a vast robot test field in Minami-Sōma that allows testing robots in simulated real-world conditions. According to many sources, the lack of suitable testing environments has been the main setback to speed up the work of cleaning Fukushima. Test fields provide images of actual obstacles in the reactors, allowing companies to test their designed technologies before deploying them. Ishikawa Jin, head of the Fukushima Innovation Coast Framework's operations planning section, said: "I want this to be somewhere the robotics engineers of tomorrow can hold study camps," on the newly built research center ("Innovation from destruction," 2020). This simulation center presents another hope to Japan's energy industry as it worked hard since the disaster to repair its local and global reputation. Ishikawa's desire to make Fukushima a place "associated internationally with robotics, not a disaster" would have taken a leap in the World Robot Summit ("Innovation from destruction," 2020). The summit, taking place in the Fukushima area, was scheduled to take place in mid-August 2020 at the Fukushima Robot Test Field. However, due to COVID-19, the summit has been postponed until further notice. By holding the World Robot Summit, Japan was hoping to revive Fukushima's local businesses and create more employment opportunities. The summit would have also helped repair Japan's energy industry reputation and Fukushima, a place where one of the worst nuclear disasters took place, as a "burgeoning hub for robotics" (*Innovation from destruction,* 2020).

4.2.1.2. A False Hope to the World?

Developing dexterous, fully mobile machines that would adequately respond to future disasters will take many years. Rian Whitton, a senior analyst for ABI Research, said, "Fukushima was a humbling moment. It showed the limits of robot technologies" (Cheng, 2019). The reason Fukushima's repair has been taking this long, is the unknown environment robots are designed to operate in. According to Hajime Asama, a roboticist at the University of Tokyo, until the bots are sent in, the conditions remain unknown. Once they are sent, it becomes hard to change them. According to Cheng (2018), robots sent in had to be small, able to swim, and powerful enough to drag as much as 65 yards of electric cable behind them. Each robot then gets equipped with the needed tools for the goal of its operation. These characteristics made it more challenging to design robots for specific operations, given that once robots are stranded inside the reactors, engineers do not have the chance to learn what could be improved in their future designs. Thus, competitions such as DARPA present a window of possible designs and developments that could add to the dexterity and efficiency of the deployed robots. Sadly, the robots highlighted in the challenge as possible designs for Fukushima were "nothing more than concepts" (Matthews, 2018).

The nuclear disaster's unfolding risks subjected the incident to global media attention, which has forced the government to act accordingly and repeatedly state full control of the situation. Unfortunately, the disaster's local and global coverage allowed a great deal of misinformation regarding the incident. This has increased the level of uncertainty over the disaster, and the public started calling for more transparency upon the government's attempts to resolve the crisis. In addition to this, another ethical concern amid the disaster is the maximum radioactive exposure level allowed. A question worth asking: What will happen when workers reach the maximum allowed radioactive exposure level? In 2015, due to the lack of skilled decontamination workers, the Nuclear Regulation Authority (NRA) wanted to increase the authorized limit per worker ("Japan to raise worker emergency," 2015). In normal circumstances, nuclear workers are each allowed a maximum dose of 20 mSv per year, and if that limit is exceeded, the worker cannot work for the rest of the year. The Nuclear and Industrial Safety Agency permitted the workers at Fukushima Daiichi doses of up to 250 mSv amid the disaster in March 2011. The limit was then lowered back to 100 mSv in December 2011. According to the International Atomic Energy Agency, workers are allowed to receive up to 100 mSv per year in case of an emergency.

100 mSv is the level where the risk of cancer is still not prominent, but above that level, the risk becomes apparent (Sutou, 2016). The decree was later abolished; nevertheless, it raised a question of whether human health is worth the risk of profiting from energy. Moreover, how many safety guidelines are implemented to protect people's lives when such nuclear projects arise? Once a disaster hits, people immediately start calling for robot technologies to save the day. The duration these technologies take to mitigate the impacts of an incident and completely solve it determines whether they have succeeded in containing the disaster or not. After that, whether these technical solutions offered a short-term resolution to the given problem with or without long-term impacts determine the type of rising ethical concerns. It also plays a critical rule in shaping public opinion on robotic technologies.

4.2.2. Lessons Learned

The impacts of the Fukushima Daiichi nuclear disaster in 2011 are still seen today, but the world now has the opportunity to learn from it. This disaster has shed light on many personal, organizational, political, and cultural failures, but it also presented broader lessons. In times of failure to contain a disaster, the crisis management system, especially the approach to the problem, needs to be reformed (Yoann & Thierry, 2014). In the wake of the disaster, and in an attempt to prevent any future nuclear crisis, Germany and Japan sought to abandon nuclear energy and turn to renewable energy (Yoann & Thierry, 2014). However, their decision to eliminate nuclear energy has long-term impacts on the economy, environment, and medical research ("Uses of Radiation," 2017). Nuclear research helped create medical innovations, such as contaminated waste treatment. Furthermore, abandoning nuclear energy will lead to increased dependence on more gas, oil, and coal consumption, all of which play a critical role in environmental pollution. Therefore, it is vital to thoroughly consider ways to prevent a similar incident in a future setting while working on fixing the current problem.

Another essential lesson upon Fukushima's disaster is the need to develop emergency response robots that could be immediately deployed when a crisis hits without the need for additional development or time for adaptation. It is difficult to predict a disaster, and often a disaster such as the one in Fukushima happens very quickly. Therefore, further research and work should focus on increasing the efficiency and effectiveness of current robots and AI systems and reducing the reliance on adaptation and manufacturing during or after future crises. As a step to begin developing robotic first responders, the US's Department of Defense and a South Korean research team are working on simulating a 3-D model for the Fukushima disaster site and developing algorithms to enhance the robots' deformed objects recognition (Cho, 2017). Their work is meant for future crises of different types; however, they chose to focus on nuclear sites because, in their opinion, nuclear sites are more complicated than other places. Selecting severe disasters to begin working on is a helpful tactic; if their work succeeds, it will succeed in any less severe hazard future setting. Future incidents might require more tasks than could be found in current robot technologies, but robots prior to the disaster can at least then start cleaning up the area until other developed robots arrive.

5. Conclusion

In the midst of the coronavirus outbreak, people started to realize the increased need for automated machines as well as the everlasting apprehension of AI infringement. AI algorithms have shown some extraordinary developments in applications over the span of the past years, but there is much more that needs to get fixed in these algorithms before they ought to get implemented on a wide scale. Besides, it is imperative to regulate access and release of collected information during and after the disaster to ensure ethical use of data by private companies and organizations. Robots have additionally demonstrated their capability as a disaster relief technology. A robot might wind up assisting with small repetitive tasks that help diminish the stress off of humans or with carrying a huge part of the task to protect the lives of humans. In any case, in a crisis when a robot has to supplant workers, humans' remote presence will still be required in the event of an error in robot operation. Immediate robot response to a disaster must be considered with an awareness of potential negative implications.

Throughout the project, it was observed that rising problems trigger technical responses, yet in the event that a response took a long time to arrive at the scene, the public got disappointed. This is indeed what happened after the Fukushima Daiichi nuclear disaster. Engineers and roboticists must learn from the still ongoing disasters, and develop more productive tools that could be quickly deployed to future disaster scenes. To do as such, it is fundamental to test those apparatuses in real-world scenarios so that they would play a more prominent role in future disasters. This project report was composed while the pandemic is still surging and Fukushima has not yet been thoroughly cleaned up; thus, discussions and conclusions reflect only up to the date this report was submitted. This project could also serve as a reference to future work exhibiting robot and AI ethical issues during an urgency.

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