Fault Safety During Direct Human Robot Interaction

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

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Spring 2023

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

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STS Research Paper

Introduction:

The automation of various tasks has continued to increase over time as technology evolves. The tasks being automated are now stretching outside the industrial environment, such as a McDonald's in Fort Worth, Texas in which the order is processed and handed to the customer completely automatically (CBS). Such systems are a novel devopment because they directly interact with consumers. In an industrial environment, workers can be trained to safely operate equipment, however, at a McDonald's, anybody can drive up and directly interact with industrial grade heavy equipment. New safety systems, methods, and standards must be developed to ensure consumer safety in this new environment. Questions that must be answered include who would be responsible for making such standards, how should these standards compare to existing industrial standards, and when is somebody liable for damage or injury caused by their automated equipment. In order to analyze these questions, this research paper will use the risk society framework to determine how the different risks and rewards associated with humans and robots sharing space should be handled (Mythen, Ulrich Beck: A Critical Introduction to the Risk Society).

Supportive Background Information:

It is important to understand the agencies which could enact regulation. One possible agency would be the Occupation Safety and Health Administration (OSHA). OSHA does not currently have any robotics industry specific regulations, but already has industrial regulations and standards for industry (OSHA). Any robots which deal with consumers but exist in the workplace, such as an automatic bartender, would have to abide by all OSHA regulations. The Consumer Product Safety Commission (CPSC) could also regulate robotics if they are sold directly to consumers (CPSC). They could also issue recalls of products that they deem to be unsafe. While neither organization would fully cover the range of consumer facing robotic products, any currently conceivable product would be covered by at least one.

In order to discuss the safety of the interaction of robots and the publicit is important to understand safety concepts in an industrial environment. One important concept is the idea of controlling hazardous energy (OSHA). A robot should be able to be completely deenergergized such that there is no mechanical or electrical potential energy which if mistakenly released could cause injury. The exception to this rule is if deenergizing equipment would also deenergize related safety systems. Other sources of potential energy such as chemical are included as well, and would usually be applied by using safe materials and batteries.

When determining liability, it is important to understand the basics of how it is determined. Following all regulations and standards applied to a product can in some cases protect a company or manufacturer from liability, however, this does not apply to defects (ALEC). Generally, liability is highly situational and depends on the state. ALEC provides ways for states to ensure that their state legislation meshes well with federal regulation (ALEC). Defective products fall under strict liability, where a company can be liable regardless of intent if it is considered defective (Cornell).

STS Framework:

The primary framework to analyze safety considerations will be the risk society (Beck). The risk society thesis sets out to analyze how risk and society's perception of risks affects development. Risk itself does not have a truly agreed upon definition, which complicates the issue and makes risks impact on technological and sociological development less concrete (Mythen, 2). The framework can be applied to the safety of robotics because people will behave differently based on how they perceive risks. If humans and robots are to occupy the same space, then it is crucial that engineers be able to predict how people will typically interact with their creations. It is also important for engineers to be able to accurately portray the safety risks of the robot both for public knowledge as well as a regulatory guide.

Mythen uses an example of how risk affects society by using 9/11 as an example. Mythen cites people differing behavior before and after 9/11 of an example how people will change behavior based on how fearful they are of certain risks (Mythen, 2). Thus, it is important that the public be appropriately cautioned of the risks of interacting directly with robots as well as not overly fearful. How engineers and businesses portray the dangers of their products affects how society uses or misuses them.

One criticism of risk society focuses on how it proposes that risks can profoundly impact society, and then frames everything as potential risks. In this way, if society were to use the risk society thesis to analyze everything they may get an overexaggerated sense of the risks people face, and thus become affected negatively by it (Mythen, Beyond the Risk Society, 231). The paper will still use the risk society as a tool because it is anaylzing something that is already considered a potential risk. So long as risks are appropriately judged, using the risk society to analyze safety measures will help to contextualize the potential impacts and perception of robotic systems if they are to interact directly with people.

Research Question and Methods

This research paper analyzes the safety standard that society should expect of robotics when they interact directly with people, especially consumers. The paper considers the behavior of the robot during a fault, and the consequence it could have on the person interacting with the robot. The paper looks at industrial safety strategies and their limitations, how regulation could be used to increase safety, and examines who is liable in the case of an accident. The paper gathers evidence through the use of documentary research. Governement regulators have extensive documentation and case studies involving current regulations and how they apply to products. These are used to anaylze how existing regulations affect robotics as well as how they can be changed to adapt to new needs. The Virgo search tool is used to search for books and other studies that have analyzed the safety of robots and humans directly interacting. The research question being asked is how fault tolerant should robotics be when allowed to interact directly with a person, how can this tolerance be achieved through reusing industrial standards and regulation, and who would be liable in the event of an accident?

Results and Discussion

In order for robots to be able to safely interact directly with humans, software based safety systems will have to be able to be trusted and tested to handle faults. When just powering off in the case of an error is dangerous, software must be there to keep the robot in a safe position. Since most industrial applications can simply power down in the case of a fault, new regulatory and testing strategies and standards must be created to ensure that the software controls in the devices are safe.

Reusing Existing Industrial Stragies

Many of the concepts from industrial environments can still apply to a consumer environment. For example, deenergizing equipment that is not active helps prevent the energy from being expended in a harmful way (OSHA). Equipment that is off should stored in a rested state. If equipment is on and experiences an error, in an industrial environment it can simply power down to deenergize safely. In an environment where direct collaboration with a consumer is occurring, however, a sudden deenergizing of the equipment could lead to injury or harm to the person interacting with it.

An example of a situation could be for a mine rescue robot, in which a robot attempts to rescue workers trapped in a mine. Hazardous conditions can make it extremely difficult for rescuers to reach people trapped within a mine, and thus it is favorable to have a robot do the job instead (Reddy). In rescuing, the robot may have to assist an injured person to get through a hazardous site. If the robot were to encounter an error while supporting or otherwise carrying the individual and immediately deenergize, the person would be in position to absorb some of the mechanical or potential energy being released. If the robot cannot be depended on to handle such errors, then it may be better to avoid using robots altogether, in the hopes that conditions could improve enough for a human to do the job. If the robot were to have software controlled safety sytems that were trusted to handle faults, then mining rescue robots could be a valuable and safe tool for rescuers to use.

Another example would be from automated fast food restaurants, a few of which have started to appear (CBS). This situation is also different from the mining robot in that it would be accessible to any consumer, not employees who could have at least some form of training. The machinery would have to at some point hand the food off to the customer. The implication is then that the restaurant machinery and person must at some point occupy the same or a similar space. An automated drive through window would need to allow a person to stick their hand through it, be able to close, and lock itself in order to prevent unwanted access. If the machine encounters a fault while the door is open, the door cannot be safely closed because someones hand could be inside of it, but powering down and leaving the door open now allows some access to a malfunctioning machine. Software that remains operational could safely analyze the situation and close and power down the necessary mechanisms at the appropriate time. Again, software safety systems can be utilized to ensure safety where simple deenergizing techniques leave oppurtunities for accidents.

The risk society framework posits that technology can and has changed the distribution of risk in society (Mythen). The mining rescue robot would have the ability to distribute risk from the rescuer to either the robot by replacing a person in a dangerous situation, or to the miner by replacing a human resuer with a less effective medium. Which one happens depends on the robustness of the robot implementation. The automated fast food location creates a notably less humanity oriented risk redistribution. It redistributes financial risk from the restaurant to safety risks to consumers. The reduced finalcial risks of the restaurant could allow them to lower prices to outcompete other restaurants, but this effect would be difficult to measure. It also begs the question of whether people would and should want to sacrifice a little bit of safety for the best case of some cheaper food. If people did, it would validate Ulrich Beck's assertion that general risk in society has increased over time due to technology (Mythen).

Creating New Safety Standards

If untrained people are to every be able to interact directly with robots, then existing regulatory standards will need to change. It is a commercial establishments duty to warn customers of a wet floor hazard (Enjuris). It is natural then that they also have a duty to warn customers of robotic hazards. Industry has standardized GHS symbols to represent dangers which are designed to be immediately and obviously recognizable and are required in the workplace (Princeton). An automated restaurant would be a workplace and therefore have them, however, employees are trained to recognize these symbols, while a child in a fast food restaurant is not. While most hazards would not be accessible to a customer in a fast food restaurant, robotic hazards would have to be to do their job. Signage regulations for such robotic devices must ensure that training is not required to recognize the meaning of signage, even by children.

It is also possible that robotics, such as one that could prepare a meal automatically, would be sold directly to consumers. In this case, the Consumer Product Safety Commission (CPSC) would be responsible for regulating the product (CPSC). The CPSC currently requires that a “reasonable testing program” be done, but only specifies requiremnts for some specific products such as lighters and bicycle helmets (CPSC). Given that a robotic device which would need to cut or mix batter would need to be somewhat powerful, it would potentially provide enough risk of injury to warrant special regulation from the CPSC. The CPSC would be able to require specific tests for devices to satisfy the reasonable testing requirement. The tests would allow them to ensure that products reaching consumers can survive certain types of failures, especially those where deenergizing is potentially dangerous.

Robotics would also be useful for potential medical uses such as assistive devices designed to increase mobility or help with a disability. These devices would be regulated by the Food and Drug Administration (FDA). The FDA does not have to change its regulation for consumer robotics because it has already started dealing with them, and can simply require that a product submit a premarket notification and get written approval to sell a product (FDA). A device must be exempt in order to sell the product without a premarket notification (FDA). New and unique products would not be on the exempt list, which makes the FDA regulation very resistant to emerging technologies such as robotics.

If Beck is correct in asserting that society has favored increased risk over time, then it is especially important that regulations across a variety of products are resistant to emerging technologies (Mythen). While too many restrictions of new technologies can hinder technological progress, having too few can distribute risk unfairly and increase overall risk in society. For robots that interact directly with humans, a stricter regulatory style requiring explicit approval makes more sense than a more relaxed regulatory style because of the human cost of failure. In situations where deenergizing is potentially dangerous and software is needed for safety, testing should be thoroughly documented and reviewed to ensure all corner cases are tested for.

Liability of Manufacturers

The introduction of robots to public settings will inevitably result in at least a few accidents. It is important for consumers to understand how responsible they are for their own safety, as it will affect how they interact with robotics in public. Generally, following safety regulations makes a company not liable for damages, so long as no negligence is involved (ALEC). For an automatic fast food restaurant, this would mean that the equipment was all properly inspected, all the proper signage was there, and the injured person did not make reasonable decisions in the process of getting hurt. For a medical assistive device, the FDA approval would generally protect the company except in the case of defects in the product (ALEC). While more restrictive regulations help prevent dangerous products from reaching the market, they can also shield companies from liability.

It also must be considered whether a manufacturer or commercial business has responsibility for an accident. If a restaurant buys a piece of equipment that fails, is the restaurant at fault because it happened on their property, or is the manufacturer of the device responsible. Laws depend on the state, but generally any company in the chain of distribution of the product in question can be liable (Goguen).

Ensuring that liable companies can be held accountable is important because it helps distribute risk from the consumers and users of a product to the manufacturers and sellers of a product. The distribution of risk is important so that each party has an incentive to test a product and use it responsibly.

Further Exploration

Limitations of this research include the tyoes of software controls that can be used as well as effective technical strategies. Further exploration is needed to determine specific starategies as well as ways of rigourously testing to ensure regulations are followed. The research ould also be expanded to the possibility of stochastic AI models being used as safety systems. These syetms would be much harder to test rigorously, and thus would eb much harder to regulate.

Conclusion

In conclusion, robotics can safely interact directly with people only with appropriate software safety controls to handle faults. Regulatory bodies such as the CPSC and FDA can create rules requiring specific tests for these software systems in order to ensure that they work. Furthermore, regulations can ensure liability for companies that make or sell defective products, creating an incentive to increase safety and distributing risk from the consumer more evenly. Although software controls can be harder to ensure safety for, it allows for much more complex technology which could improve the lives of many people.

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