Automatic Checkers Robot
(Technical Paper)

Safety and Direct Human Robot Collaboration
(STS Paper)

A Thesis Prospectus
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By
Matthew Ippolito

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Technical Team Members:

Emmanuel Erhabor
Nicky Palmer
Matthew Hankins

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.

ADVISORS

Harry Powell, Department of Electrical and Computer Engineering

Bryn E. Seabrook, PhD, Department of Engineering and Society

Introduction

Seeing blue light before going to bed, especially from screens, can disrupt a person's circadiamn rhythm by suppressing melatonin release (Harvard Health). Therefore, it is important that screenless entertainment devices be created to decrease blue light exposure. Robotics could be employed to provide a more haptic and personable experience than a screen in addition to reducing blue light exposure. These robots, which would be directly used by consumers, would need to have additional safety features which are unnecessary in the industrial arena. As time progresses, robots will no longer be able to be hidden behind a protective barrier, and thus will require robust safety protocols and error handling standards. Consumer robotics will also not be able to be constantly inspected as in industry.

The technical topic of this prospectus is a automated checkers playing robot. The robot will be able to automatically play checkers against a human opponent. The robot and the human opponent will both have to occupy the space above the board, thus requiring several safety features. In order to ensure safety within the design, the safety of robotics in a consumer setting will be researched as the STS topic of this prospectus. The combination of a technical design of a robot intended to be operated by untrained individuals as well as research into safety guidelines for robots and humans in shared spaces will provide both a theoretical and practical understanding of robotics safety. It will be important to ensure that safe operation of the technical project is immediately evident and effective at preventing dangerous malfunction. As such, the STS research question of this prospectus is how safe should a robot be for it to be considered safe for consumers, and what standards exist or should be added in terms of regulation?

Technical Topic

The creation of an automated checkers playing robot will create a single player version of checkers that does not require a screen. The project will be created in a team of four people, two of which are computer engineering majors, and two are electrical engineering majors. The robot will also be more human than a phone or computer because of the physical mechanical interaction with the game. The game will use the same medium as an in person checkers game between two people. We will also have to consider the safety of the robot. Building the project will require us to gain experience with actual regulation of consumer devices, such as from the Consumer Product Safety Commission, whose goal is "to protect the public against unreasonable risks of injury associated with consumer products," (U.S. Consumer Product Safety Commission). The practical experience gained from considering a real robotic device will assist in researching the STS topic of this prospectus.

We plan to create a gantry with a solenoid and electromagnet to move the pieces. The gantry will use the OpenBuilds parts ecosystem to create an effective movement system (OpenBuilds Parts Store). The solenoid will extend, and a powered electromagnet will be able to stick to individual checkers pieces, which will have a metal material in them. We will use Solidworks to plan the design of the gantry (Dassault Systemes). In order to ensure safety of the gantry, appropriately powerful motors will be used, as well as multiple flashing warning lights and an emergency stop.

In order to recognize the pieces on the board, we plan to use image recognition. The piece will be brightly colored, allowing the camera to identify the pixels which are part of the pieces. We will utilize the OpenCV image recognition library in addition to a custom clustering algorithm to identify the location of each piece within the image (OpenCV). The image recognition code will run on a Raspberry Pi microcomputer (Raspberry Pi Foundation). The

process will use separate pieces for king pieces which have a yellow ring surrounding them. The robot will take the image and process it through a modified form of an already existing checkers algorithm, which navigates a tree of all possible moves, and removes ones it considers to be bad.

The motors, solenoid, electromagnet, and user interface will be controlled by a MSP430 microcontroller (Texas Instruments). The user interface will consist of buttons to control when the robot attempts to make a move as well as when to start the game, as well as several indicator and warning lights. The MSP430 will be able to respond and act deterministically as a real time system (Texas Intruments). Reacting deterministically is important both for usability and safety reasons. The motors will be bipolar stepper motors, which will allow precise tracking of their location. The solenoid and electromagnet will be able to be run with pulsed signals, thus reducing their average energy requirements. A final report will be created to summarize the design as well as difficulties encountered during creation.

STS Topic

When purchasing a product, safety is a crucial consideration for both consumers and regulators. Certain products can present risks that consumers would not fully understand on their own, as they are not experts. It is therefore up to manufacturers and regulators to ensure that consumers are informed of potential risks and safe use of products. Robotic devices are becoming more common as consumer products, where they can interact directly with people. As these devices are newer, less regulation exists, which can impede the development of new robotics due to the uncertainty of liability in the event of an accident (Barattini, 15). The STS research question of this prospectus is how safe we need to consider these devices to be in order to be fit for consumers, and how existing regulations need to change in order to adapt to this emerging technology.

Firstly, there are different ways a robot can achieve safety. A robot can be designed such that in the event of an accident, damage is inherently minimized, which is called intrinsic safety, and interactive safety, where the robot actively attempts to prevent accidents (Liu, Tang, Lin, Tomizuka, 45). Ideally, a robot will have both, however, due to computational and functional constraints, this is not always possible. Different products will have different abilities to achieve intrinsic and interactive safety. When considering how safe something should be for consumers, the ease of implementing certain safety features should be considered. Having all consumer robots constantly monitored would certainly improve the safety of the device, but is extremely impractical. Consumer robotic devices have many potential uses, such as making smart manipulators and prostheses, as well as smart wheelchairs and can even be used for educational purposes (Encarnação). Setting a safety requirement that is too high would stifle these technologies which have the potential to change people's lives. The STS research paper will balance risk with the potential benefits to individuals and society.

Equally important to setting a risk threshold is implementing policy to ensure that the risk threshold is reflected in society. The first step in creating regulation is to identify potential hazards that are to be avoided or mitigated. There are already several ISO standards for potential hazards, many of which identify components such as batteries, which can be dangerous if they fail (Encarnação). Such standards can be supplemented by specific regulation in order to ensure compliance. Existing regulation in the United States for consumer products is handled by the Consumer Product Safety Commission (CPSC) (U.S. Consumer Product Safety Commission). The STS essay will analyze how the CPSC specifically can introduce new regulations for robotics to be introduced to consumers. It will be helpful to reference OSHA standards, which already contains regulation surrounding heavy machinery. It is important to note however, that

not even OSHA has regulations specifically for the robotics industry (U.S. Department of Labor). The STS paper will interpret how existing OSHA regulations can be modified and applied to benefit consumer safety.

The STS paper will use the framework of the risk society (Mythen, Ulrich Beck: A Critical Introduction to the Risk Society). By framing the safety of robotics as a risk, the paper will be able to analyze the benefits and drawbacks of potential regulatory ideas in order to find an appropriate balance. One criticism of the risk society is that framing everything as a risk has profound societal consequences. It can create 'manufactured insecurities' if risk is not appropriately judged (Mythen, Beyond the Risk Society, 231). Because consumer robotics have many applications in accessibility, presenting them as a greater risk than they are could lead to society stifling an industry that improves accessibility. Certainly, it will be important to accurately reflect the risk of robots in the STS paper.

Research Question and Methods

Documentary research will be used to gain information about the topic. Many studies involve mitigating risk in heavy machinery have been created, and general guidelines compiled into books. Specifically, studies which analyze software techniques to create safe motion paths will be analyzed as well as existing regulations for heavy machinery in industry will be used to see what risks have been identified and how effectively they can be mitigated. The Virgo search system from the UVA library will be used to find a variety of published books and academic studies for robotics. Robotics in industry will be used to project onto the consumer sphere, thus showing gaps in existing consumer regulations that would be useful for robotics. The research question contains both a general safety minimum discussion, as well as how to guarantee that

minimum through regulation. Robotics will be viewed as a risk that society must deal with, and regulations and standards as how they are dealt with.

Conclusion

In conclusion, in order to gain an understanding of safety, both a practical implementation of a checkers playing robot as well as an essay concerning the safety of robotics will be created. The checkers playing robot will create a more personal and screenless single player checkers game. The design would be for consumers, and thus to create a safe implementation, consumer safety and regulations must be studied. To accompany this, the STS paper would include general research about the topic and how aspects have been implemented in the design. It will do this by analyzing how society and engineers deal with the risk associated with a mechanical device interacting in the same space as a human. The combination of theory and implementation will create a robust capstone experience.

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