Ball Bearing Clock

(Technical Paper)

Evolution and Societal Fears of Robotic Manufacturing

(STS Paper)

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

Introduction

The robot revolution offers great opportunities and great risks to American society, economics, and politics. 28,478 industrial robots were sold in the United States in 2018 which is a 16% increase from the previous year (Aeppel, 2018). Robots are being used in industrial applications at ever increasing rates due to their faster speed, higher quality, and lower cost than traditional manufacturing methods. However, a recent CNN article suggests that robots will take 20 million manufacturing jobs by 2030 (Tappe, 2019). The article portrays the common American belief that automated robots will replace humans in a myriad of industries, ranging from automotive manufacturing to fast-food cooking. The STS research topic discussed in this prospectus will analyze the evolution of autonomous robots in manufacturing, societal fears caused by this technology, and the emerging alternatives. The technical topic of this prospectus will focus on the design of a magnetic ball bearing clock. The clock will use moving permanent magnets to levitate ball bearings in the shape of digital numbers. This project will be displayed as a functional piece of art in the Mechanical and Aerospace engineering building. It will serve as an example of advanced manufacturing techniques and the utilization of computer aided design in the creation of a final fully functioning reproducible product.

Technical Topic

The core idea of this capstone project is to create a piece of kinetic art that also functions as a digital clock through the deployment of magnets to cause ball bearings to display the time. Kinetic art is any form of art that moves, often offering a useful function through its motion. The clock will take advantage of magnetic forces to levitate ball bearings on the clocks front surface creating an awe-inspiring illusion. The clock will have the same functions as any other digital clock, such as the ability to display time in the traditional format, and able to be reset to account for daylight savings or loss of power. The clock will be designed to be displayed on the second floor of the Mechanical and Aerospace Engineering building. The clock will be powered by a standard 120V AC wall outlet.

In order to control whether or not a section of a digit will be displayed, two options were presented: electromagnets or actuated permanent magnets. Electromagnets could be kept in a fixed position and either be turned off or on depending on the numeral displayed. Alternatively, permanent magnets could be actuated closer or further to the front face to change the strength of the magnetic field acting on the ball bearings allowing for certain segments of the numbers to be turned on or off. Ultimately, the option of using actuated permanent magnets is optimal due to concerns with the amount of power electromagnets would consume in holding the bearings for long periods of time.

The movements of the magnets will be accomplished through the use of an RC servo motor which will either pull the magnet away from the clock face to turn that segment off or push it forward to turn that segment on. The coordination of these servo motors will be accomplished through a Parallax propeller microcontroller chip to utilize its parallel processing and internal clock features. The clock will also utilize a servo motor controller chip to allow the microcontroller to easily control all 23 servo motors used in the clock.

The strategy devised by the group is to make iteratively larger and more complex prototypes. First, a prototype of a single section of a digit will be made to test the servo motor and magnet interactions. Next, a prototype of a full digit including all seven motors and magnets will be made. After the second prototype, the dropping mechanism to place the ball bearings onto the clock face will be added. This mechanism will include a spinning wheel and reservoir which will run up and down the clock face to place the ball bearings against the magnets as the time changes. Finally, four digits will be manufactured and put together to create the final product. The clock will be designed and built by the capstone project team under the supervision of Professor Garner. The final product will be finished and delivered by December 12th, 2019. Tools essential to the success of this project will be the utilization of Computer Aided Design (CAD), advanced manufacturing techniques, such as 3D-printing and laser cutting for the purpose of rapid prototyping, and the use of iterative design techniques to overcome challenges as they appear.

STS Topic

Autonomous manufacturing has become a new and exciting technology in the United States and around the world. Manufacturing is defined as a process that is mechanical, physical, or chemical that transforms raw materials into a new product (Yin, 2016). Manufacturing is a large and important industry in the United States accounting for nearly 11.6% of US economic output (Amadeo, 2019). In addition, manufacturing companies supply nearly 12.85 million jobs, accounting for 8.6% of the American workforce (Amadeo, 2019). Automating these manufacturing processes has many benefits over traditional manufacturing techniques, including an increase in speed and quality and a decrease in cost (Fleck, 1984). The automobile industry has taken advantage of these qualities since the first industrial robot was introduced into a General Motors manufacturing plant in 1964 (Robinson, 2016). Since then, industrial robots have become commonplace in many industrial applications.

With the increase in manufacturing automation, there has become a strong public opposition to the use of robots in industry in the United States. The majority of this opposition comes from the perception that robots will replace human workers in countries with large manufacturing industries, like the United States. Many industry workers worry that they will lose their jobs to robots as the technology becomes more abundant (Chao, 1986). This fear has large and far reaching implications. Some economists believe that robots will cause immediate job loss in lower wage communities contributing the pay inequality in the United States and other parts of the world (Berg, Buffie, & Zanna, 2016). Americans also fear this unemployment could lead to a failing economy, which would have political implications affecting the United States relationships with other strong manufacturing countries, such as China, Germany, and Japan (Cellan-Jones, 2019).

While this idea that robots will replace humans in the manufacturing industry is common among the public, there are many researchers who argue that automated manufacturing will not cause the detrimental impact the general public believes will occur (Paul). Completely automated robotic manufacturing is an extremely complex task and the technology required for it has not been fully developed yet. Most advance manufacturing techniques are designed for a specific task making it rare that they can encompass a whole occupation (Bloomberg, 2018). For example, a group of Chinese companies are attempting to convert their manufacturing plants into completely automated systems with no human input; however, they are finding it difficult to remove the human worker completely (Knight, 2016). More importantly, robotic technology is being implemented in factories to boost production making companies more profitable allowing them to expand and hire more workers (Elliot, 2017). Overall, the public fear of autonomous robotic manufacturing may be misplaced.

An emerging alternative to traditional industrial robots is the cobot. The term cobot stands for collaborative robot, and it is a robot that works side by side with a human counterpart to complete a task ("Industry 4.0," 2018). The robot is designed to take care of the strenuous and tedious tasks, while the human worker handles the more complex ones. Cobots have been found to increase productivity tremendously and allow for greater flexibility of use in the manufacturing process. These robots are cheaper to acquire, allowing small and medium sized companies to implement them at small scales. A cobot's ability to be reprogrammed and complete a different task offers a new ability that most modern large-scale manufacturing robots do not possess. It is estimated that cobot sales will account for 34% of all industrial robot sales in the years to come compared to only 3% in the past (Hitch, 2019). These statistics show that the cobot is an excited alternative taking hold in the manufacturing industry.

The theories that will be used to discuss this STS topic will be the theory of a risk society and actor-network theory. A risk society is one in which "a threatening future, still contrary to fact, becomes the parameter of influence for current action" (Beck, 2000, p.222). An automated robotic manufacturing system presents a threatening future due to modernization. Automation is a technology that has been developed to increase productivity and quality of various manufacturing processes. However, this modernization has many risks associated with it. These include job loss, economic decline, and political change. These risks have instilled fear in people throughout the country. Automating technology is driving current change and dictating actions in the present. Actor-network theory will be used to describe the interactions between various actors, including companies, workers, consumers, and the technology itself. These interactions can expose explanations for the implementation and effects of robotic technology on society.

Research Question and Methods

The research question that will be analyzed is: What is the evolution of automated robotic manufacturing, and what are the societal fears, and possible alternatives to this technology?

The answer to this question may have large and lasting impacts on society in the United States. Autonomous manufacturing and the possible change to the American economy could change the lives of not only United States citizens, but also people around the world. This equipment has the possibility of becoming a disruptive technology causing long lasting changes for many years to come.

All research will be completed during the spring 2019 semester. The methods that will be used to answer this research question are documentary research, historical case study, and network analysis. Documentary research is the collection and organization of various articles and research papers. This will facilitate the discovery of background information and data to answer the proposed question. The historical case study will consist of analyzing the evolution of automated robots in the automobile industry. Nearly half of all industrial robots sold around the world are used in automobile manufacturing, so information gained from this study will offer insight into how the technology may be introduced into other sectors (International Federation of Robotics, 2016). Finally, network analysis will involve analyzing the various actors surrounding autonomous manufacturing. These actors are the technology itself, companies utilizing this technology, workers hired by those companies, and consumers of goods. By understanding the nature of these actors, how they interact with one another, and the decisions they make, societal fears and emerging new technologies can be understood.

Conclusion

This prospectus has outlined the topics for the technical project and STS research project. The technical project is devoted to developing a functioning kinetic art clock utilizing magnetic forces to display ball bearings in the shape of digits. The topic of the STS research project will focus on the societal fears surrounding robot automation in manufacturing in the United States. The research project will also investigate emerging alternatives to the standard industrial robot. Answering this question will shed light on the truth surrounding automated technology and possibly quell associated societal fear. Both of these projects focus on the broad concept of automation. The clock must be able to work on its own at all times for years without the need for repair of calibration. Similarly, robotic manufacturing utilizes autonomous technology to accomplish a task without human intervention. Both technologies must work without user input and without constant repair and changes.

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