USE OF COMPUTER VISION AND MICROPROCESSORS FOR RESISTOR SORTING

EFFICACY OF AUTOMATION IN THE WORKFORCE

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Engineering

By
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October 31, 2019

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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.

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Harry Powell, Department of Electrical and Computer Engineering

Circuit design is a fundamental topic covered in courses taken by electrical and computer engineering students. At the University of Virginia in particular, students are required to take the Fundamentals of Electrical Engineering series, a three course sequence covering all aspects of circuitry. The first semester that a student begins these courses, it is mandatory for them to purchase a lab kit that contains circuit components. This kit includes, but is not limited to, operational amplifiers, capacitors, and, most notably, a large number of resistors. However, as labs become more difficult and take more time to complete, students often do not take the time to sort the resistors back into the appropriate bin. Misplaced resistors then lead to mistakes when constructing circuits in the future. If the wrong value of resistance is used in a circuit, the circuit will not work as planned and, in some cases, will be unable to function at all. Though humans are prone to error that can lead to misplaced resistors, a machine that sorts resistors semi-autonomously will not make the same error. Under the guidance of Electrical and Computer Engineering Professor Harry Powell and graduate electrical engineering student Riley Christopher, computer engineering students Robyn Guarriello, Joseph Laux, and Kiri Nicholson are designing such a machine. When complete, users will be able to scan a resistor using their smartphone and the system will automatically sort the resistor into the correct container.

However, automating low-skill tasks, such as sorting resistors, has become a polarizing topic in the world today. Automation creates the opportunity to progress society into a higher standard of living and productivity but presents the risk of displacing low skill workers from their jobs and source of income (Lordan and Neumark, 2018, p.1). Tightly coupled with the technical topic, the Science, Technology, and Society (STS) research portion of the thesis will determine the efficacy of adopting automation in the workforce by analyzing both society's perception of automation and data pertaining to the historical and expected future effects of automation. The planned timeline to complete the work related to both the technical and STS topics can be seen in Figure 1 below. The technical Capstone project will be completed by the end of the Fall 2019 semester, as required by the Electrical and Computer Engineering department, and the STS research paper will be completed by the end of the Spring 2020 semester.

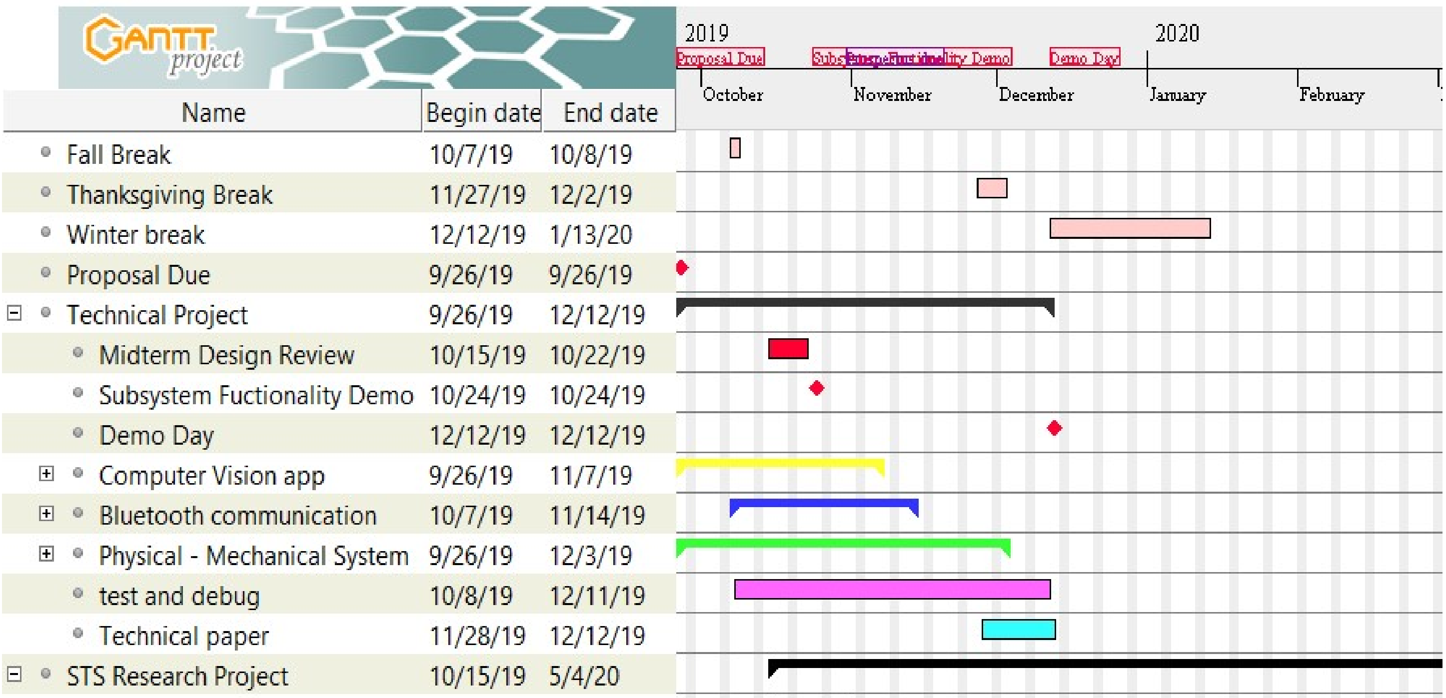
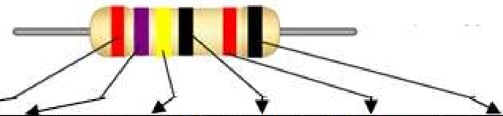


Figure 1: Gantt Chart for Projected Project Timeline: A chart outlining when each task surrounding the technical and STS projects (Guarriello, 2019)

RESISTOR SORTING SYSTEM

In a team comprised of computer engineering students Robyn Guarriello, Joseph Laux, and Kiri Nicholson, a system will be designed and tested to efficiently sort resistors into correct and separate bins. The current method to read resistor values is based solely on colored bands displayed on the outside of a resistor. These bands, shown in Figure 2, are each assigned values that the engineer must use in conjunction to manually calculate the value of a resistor. This method is prone to human error based on mistakes in calculation or misreading of the bands, and the amount of effort required to sort resistors by hand can lead to engineers skipping the sorting step completely. Any error in sorting a resistor will lead to issues when building circuits as an incorrect resistor value will hinder the circuitry from working correctly. Because of this, the team is creating a system that will significantly decrease the possibility of resistor misuse due to incorrect sorting.



Color	1st Digit	2nd Digit	3rd Digit	Multiplier	Tolerance	Temperature Coefficient
Black	0	0	0	1Ω		250ppm/K
Brown	1	1	1	10Ω	±1%	100ppm/K
Red	2	2	2	100Ω	±2%	50ppm/K
Orange	3	3	3	1kΩ		15ppm/K
Yellow	4	4	4	10kΩ		25ppm/K
Green	5	5	5	100Ω	±0.5%	20ppm/K
Blue	6	6	6	1MΩ	±0.25%	10ppm/K
Violet	7	7	7			5ppm/K
Grey	8	8	8			1ppm/K
White	9	9	9			
Gold				0.1Ω	±5%	
Silver				0.01Ω	±10%	

Figure 2: Resistor Band Values: The chart outlining what each color band on a resistor represents in the calculation of the resistance (adapted by Guarriello from Chonowski, 2017)

To achieve the objective, the team will use Bluetooth communication, a computer vision Android mobile application, and two stepper motors controlled by a mixed signal processor (MSP), namely the MSP430 microprocessor. Figure 3 shows how each subsystem will communicate and work together to sort a resistor. First, an Android phone application will scan the colored bands that denote resistance value on a resistor that is placed in front of the camera. The application will be developed using the Open Source Computer Vision (OpenCV) Library, which gives access to "more than 2500 optimized algorithms", including "a comprehensive set of both classic and state-of-the-art computer vision… algorithms" (OpenCV, n.d., para. 2). Once the application reads the bands, it will send the determined resistance value over the designated

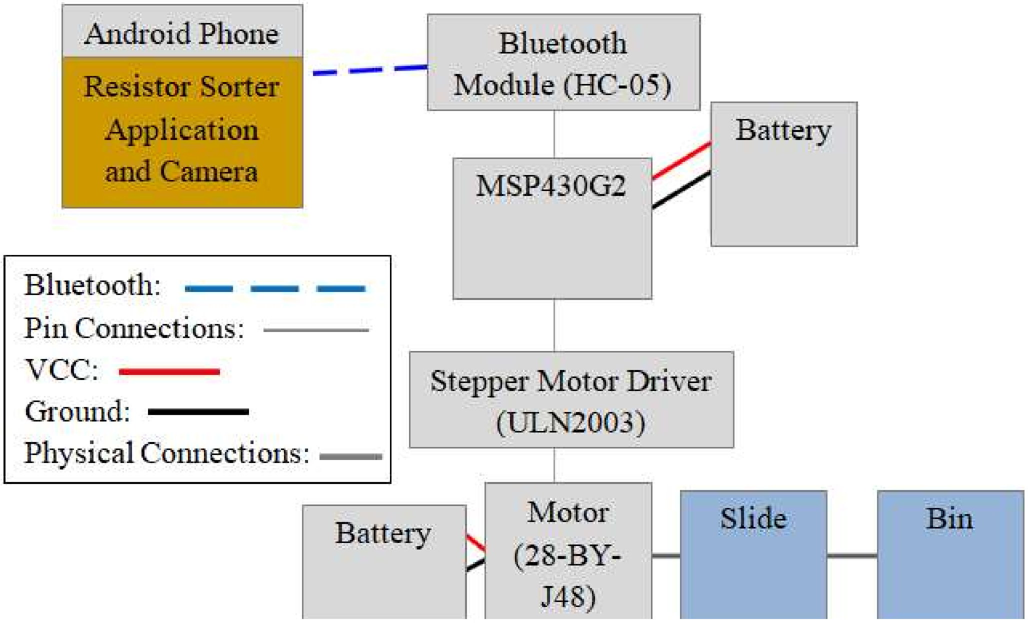


Figure 3: Resistor Sorting System Block Diagram: A block diagram showing connections between the different subsystems (adapted by Guarriello from Nicholson, 2019)

2.4GHz wireless Bluetooth channel (Blom, n.d.) to an NC-05 Bluetooth module interfaced with the MSP430. The microprocessor will then process the resistance value, determine the correct bin that the resistor is to be sorted in to, and send a signal to the stepper motor to turn a precise angular distance. Connected to the stepper motor will be a 3D printed slide, at the top of which sits the resistor to be sorted. Once the slide is rotated and lined up with the correct bin, a second stepper motor will turn a lever to push the resistor down the slide and into the correct bin. Other resistor sorters have been built in the past; however, much as described by Gross, Lambert, and Parkhurst (2016), these systems measure resistance using metal contacts that pass a current across the resistor and measure the resulting voltage. This is the same method used by digital multimeters, a common tool among electrical engineers, to measure resistance. In contrast to this technique, the technical project built for the Capstone will utilize computer vision to assess the value of a resistor.

This project is made possible because of resources provided by the Electrical and Computer Engineering department. The National Instruments Laboratory is available to all fourth year electrical and computer engineering students as a workspace to complete the Capstone project and is stocked with Virtual Benches and other necessary equipment. Additionally, the department orders all necessary parts for the project. For the resistor sorting system, parts ordered through the department have included two stepper motors, two ULN2003 stepper motor drivers, an MSP430 Launchpad for initial testing, and an HC-05 Bluetooth module.

After completing the resistor sorting system, the team hopes to have a strong knowledge of computer vision applications as well as a deeper understanding of the Bluetooth communication protocol. The team will present the process and outcomes of the technical project in a conference style paper at the end of the semester.

IS FEAR OF AUTOMATION JUSTIFIED

As technology continues to be developed, it is easy to see how efficient it is at doing mundane or repetitive tasks when compared to a human completing those same tasks. If little to no skills are needed to perform a job well, it is often relatively simple to create software or a machine to do the job repeatedly with accuracy and precision. This improves consistency between products, saves time and energy, and costs less than hiring an employee. However, there is an overwhelming culture of fear surrounding the possibility of technology gaining a stronger hold in the workforce. Sensationalist headlines such as “How Technology is Destroying Jobs” (Rotman, 2013), “Robots Could Take Over 38% of U.S. Jobs Within About 15 Years, Report Says” (Masunaga 2017), and “People Versus Machines: The Impact of Minimum Wages on Automatable Jobs” (Lordan, Neumark 2018) illustrate how society is framing the issue of automation in the workforce and the kind of media that is reaching consumers in their homes. As technology continues to grow and becomes an inevitable part of modern-day society, it is important to recognize from where the fear of technology stems and to question the biases of the mass media that is being consumed today. The STS research paper will examine the fear surrounding automation in the workforce as well as data about the historical impact of automation and its potential future impact in order to determine the efficacy of adopting automated solutions in the workforce.

IMPACT OF TECHNOLOGY ON THE WORKFORCE

Automation has been a source of debate throughout history. In the 19th century, a group of British textile workers known as the Luddites became infamous for their fear of textile machines and factories taking their livelihood, a craft that they had spent years perfecting, away from them. They began to destroy machines, set factories on fire, and attack employees in an attempt to stop the adoption of technology (Andrews, 2019). In 2017, Facebook announced that they shut down an artificial intelligence project when the bots that were created developed a new language understandable only to them. The purpose of the project was to create bots that could communicate with humans and, though the shutdown occurred solely because the bots did not behave in the way Facebook desired, the media portrayed the shutdown as a sign of rogue technology that has the potential to harm humans (Griffin, 2017). It is stories such as these that show how misunderstanding of technology leads to overwhelming fear and opposition.

Many studies have been completed to analyze the effects that automation has the potential to cause on the workforce. These studies, known as ‘future of work studies’, often focus heavily on the unemployment that will be caused due to an increase of technology in the workplace. One such study, completed by the renowned global consulting firm McKinsey Global Institute, found that nearly 33 percent of American workers are at risk of being displaced from their current jobs (Manyika et al., 2017, p.11). As shown in Figure 4, over 60 percent of jobs have potential to automate at least 30 percent of the relevant activities and over a quarter of jobs are likely to automate at least 70 percent. These statistics illustrate just how feasible it is that the entire landscape of the workforce will change in the near future, forcing nearly all occupations to alter the makeup of employees based on changes in technology, productivity, and employment costs.

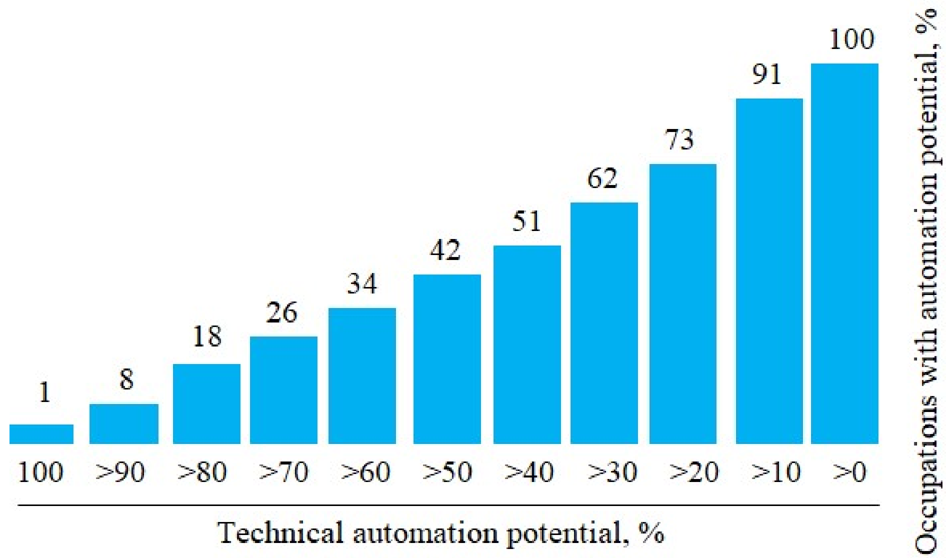


Figure 4: Potential of Automation: A bar chart showing the percent of occupations that have automatable tasks (adapted by Guarriello from Manyika et al., 2017 p. 27)

However, unemployment statistics cannot be taken at their face value. The benefits surrounding the changing landscape of the workforce must also be considered. Increasing the amount of automation that is used to complete low-skill jobs undeniably increases productivity. Figure 5 shows one example of this in history; the assembly line used to build the Ford Model T significantly increased the productivity of workers, which allowed for the price of the car to decrease, sales to go up, and employment to skyrocket. A more modern example is the creation of the personal computer. The computer led to nearly 20,000 jobs being created in fields, such as software engineering, semiconductor manufacturing, and even financial management, while only cutting about 3,500 jobs in fields such as typewriter repair, secretarial positions, and bookkeeping (Manyika et al., 2017, p.41). Susan Lund, a labor economist with McKinsey says that “[automation] is how our children could end up with a better standard of living that we have.

We want to be able to transition our workforce so that people displaced can get new jobs and we can capture the benefits without the downside" (as cited in Paquette, 2017, para. 19). It is clear that there are benefits to automating certain aspects of low-skill jobs, but the positive outcomes are often overlooked due to fear of the unknown.

With expert economists, historians, and scientists disagreeing on the potential for good due to automation, it is important to look at historical trends and outcomes. The economy and workforce is always in a state of fluctuation, and though there are difficult transition periods, especially during revolutions such as the industrial and technological revolution, "an equilibrium between the supply and demand of jobs in labor markets has always been reached historically" (Manyika et al., 2017, p.48). Just as the development of the personal computer led to a net gain in available jobs, it is likely that some occupations, such as jobs that require empathy and creativity, will see a net gain in the number of jobs available due to

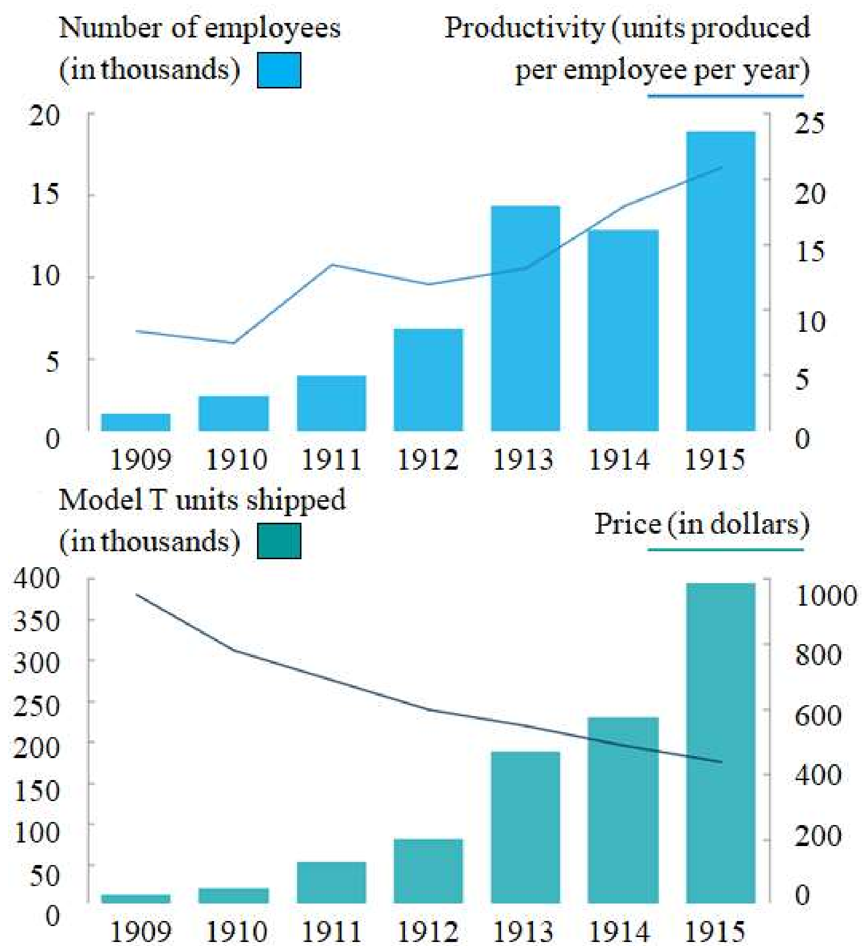


Figure 5: Effect of the Assembly Line on Productivity: A bar chart showing the increase in productivity, employment, and output and the decrease in price of the Model T due to the assembly line. (adapted by Guarriello from Manyika et al., 2017 p. 39)

automation (Masunaga, 2017). However, economists Lordan and Neumark (2018) write in a report that, while high skill workers will see an increase in available jobs (p. 50), minimum wage workers who are not highly skilled are likely to suffer the most due to automation (p. 1). Automation has the potential to create much progress and increase the standard of living drastically, and society must accept the change that automation will bring in order to reap these benefits. However, it would be naïve to ignore the inherent risks that low-skill workers will face. An emphasis must be placed on bridging the gap between those who fear the risks of automation and those who overlook the potential negative consequences in order to find a compromise that allows society to flourish in the technical revolution.

HOW DOES SOCIETY PROCEED WITH AUTOMATION

In order to effectively analyze the impact of automation, Bijker and Pinch's (1996) social construction of technology model and W.B. Carlson's technology and social relationships STS framework (as cited in Baritaud, 2009) will be used to understand how society adopts machines in the workforce. Figure 6 illustrates how to model automation through the technology and social relationships model. In the middle sits the end user, in this case the industries using automation technology. The key actors in the model, employees with low skill, employees with high skill, consumers, and employers, each have relationships with the end user that will cause them to benefit from or be hurt by their fields of employment using machines. This conceptual model will help to examine the distribution of power among actors due to the adoption of automation. If automation is to be as successful as it has the potential to be, the greatest number of actors possible must gain power and, likewise, the least number must lose. The STS research project will be written as a scholarly article that focuses on determining the efficacy of automation by weighing the risks and fear of automation against the potential to further society's standard of living. While many future of work studies exist, most take a strong stance on one side of the debate surrounding automation, leading to biased articles and reports. The STS paper, in contrast, will take an objective and historical approach when considering the implications of automation in the workforce by collecting and reporting data from credible and renowned sources that cover all points of view surrounding the debate on automation.

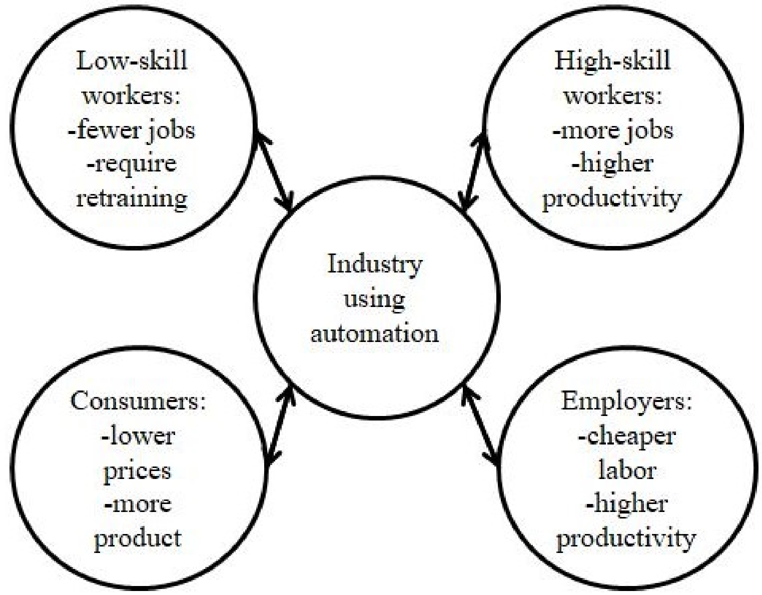


Figure 6: Automation Modeled with the Technology and Social Relationships Framework: Occupations that are adopting automation affects each key actor in positive and negative ways (adapted by Guarriello from Carlson as cited in Baritaud, 2009)

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