Portative Pipe Organ

(Technical Paper)

The Impact of Automation on the Manufacturing Industry

(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

Throughout the years our society has used technology to expedite our everyday tasks with the goal of accomplishing them in a more efficient and safer manner. In just 70 years, the industry has gone from the first automation department, Ford Automation Department in 1947, which began to work on valves and valve-guide bushings, then automated the manufacture of pistons, then coils and wheels, and then frames and rear axles, to now robotized factories fully equipped and ran by robots (Weber 2003). As the pace of technological change accelerates, ordinary tools and devices are being replaced by mechatronics products that improve their designed task and output quantity, for cheaper (NISTIR 2015). The vivid picture that most people have of mechanical systems such as gears, levers, and pulleys is now the past, while microcontrollers and AI systems lead the present. These newer systems not only come in a more compact shape and form, but their main benefit is that they allow big companies to not rely on their employees for their production.

While moving forward, especially with technology, often sounds like a great idea, organizational leaders must better comprehend the adverse effects of the technologies they implement and commit to creating systems that drive social cohesion and economic growth (B2EAutomation 2022). Former President Obama warned this in his farewell address back in 2017, “The next wave of economic dislocations won’t come from overseas. It will come from the relentless pace of automation that makes a lot of good, middle-class jobs obsolete (NY Times).” In fact, the global industrial automation market was recently valued at $150 billion, with an expected reach value of $289 billion by 2028. This CAGR (Compound Average Growth Rate) of 9.8% within the next 6 years is an increase that very few fields foresee (SkyQuest 2022). Engineers must realize the impacts that these technological changes bring, whether positive or

negative, before deciding to move forward with their idea. This paper will discuss the automatization of technology in the automotive field from an ethical perspective and will examine how the implementation of these machines has revolutionized all market industries. Specifically, it will try to see the impact of Industry 4.0 from a social and economical perspective. Following the same topic, the technical aspect of this paper will focus on how automation has impacted the musical industry by designing a fully automated pipe organ instrument.

Technical Topic

Automation has revolutionized the automotive industry and every other imaginable industry. From food to clothes production, the implementation of robotics systems is exponentially increasing. Every day, fascinating inventions that are game-changers are posted on social media. These aim to revolutionize an ordinary tool or machine with the end goal of making our everyday lives easier. Inspired by Drexel University ExCite Center, a department that uses interdisciplinary research and discovery to connect technology and communities (ExCITe Center 2012), the idea of creating a novel instrument that could be played without human interaction was brought to me in my sophomore year of High School. Unable to complete this project due to a lack of engineering experience, I saved this idea in the back of my mind. Luckily, this capstone project has allowed me to complete this project of mine. The final goal of this technical project is to donate the instrument to the Discovery Museum of Virginia, to provide younger students with the opportunity to have hands-on experience in the implementation of automation and robotics.

The pipe organ is a combination of a piano and a flute, using the keyboard keys and the pedalboard to activate valves that allow air to escape from the wind box and make resonance

with the pipe walls, producing harmonics that produce different tones. Although being one of the most complex musical instruments, “the organ has the longest and most involved history and the largest oldest extant repertoire of any instrument in Western music (Britannica 2020).” Additionally, the idea of making a mechatronics-controlled self-played organ is a project never done before, unique to the University of Virginia, which makes this project a true engineering challenge. Before starting with the build, the team set some attainable, time-bound, specific goals to be able to complete this challenge in just 8 weeks worth of work with limited money. Some of these requirements were the size factor, the materials needed, the production method for each part, the microcontroller, the air system, and overall looks and dimensions. The size factor was the biggest constraint, thus it was early agreed upon to not exceed a 2x2 ft area. The materials also were an important factor to consider, as there was limited money and tools. It was decided that most complex parts, such as the 24 flues, would be made out of ABS plastic which would be manufactured using a 3D printer. At the beginning of the prototyping process, it was decided to use acrylic for the pipe walls, as it would give the organ a modern look and it was easy to manufacture using the laser cutter; due to air leaks, the group moved on to using wood for the final product. For the brain of the machine, the microcontroller, there was a debate between using a P2 and an Arduino Uno. While the Arduino Uno provided a more familiar interface, with a substantial open-source library of code and compatibility with other market products, such as the Leap Motion Sensor, the lack of input and output pins (16 vs. 64) was the determining factor of using the P2 microcontroller. Finally, the air system and the overall dimensions were two related constraints. The air system was powered by an automatic bellow, supplying the air to the airbox where it maintained its pressure and waited for the solenoids to activate each valve, and subsequently supply the air to each pipe making a sound.

STS Topic

The relentless pace of automation is altering the world that we live in. Automation is not just changing the manufacturing field, but now is moving towards fairly new businesses - companies such as Uber are testing self-driving trucks, traveling 200 kilometers to deliver a cargo of Budwiseer (MIT Technology Review). Although these developments clearly reflect the technological achievements of automation, they also clearly reflect a looming shift in the employment market, which make engineers and economist question these changes. To put this into perspective, it is estimated that just automated vehicles could threaten, or at least alter, 2.2 to 3.1 million existing U.S. jobs (White House Council 2016). To emphasize this argument, these represent the millions of taxpaying Americans that will lose their jobs in the coming years. To add to the issue, the federal government currently spends billions of taxpayer dollars to help tech companies bring automation and other high-tech tools to market (Jose Garcia, Politico 2019). The government is using the American money, of the people whose jobs are being taken from, to fund the expansion of automation in the United States. This means that by 2030, 73 million US workers could be displaced from their jobs by automation (McKinsey 2017).

The STS portion of this thesis will focus on the ethics behind responsible innovation in automation on a large scale. The fact that automation is happening is not the problem in this situation, as it is an inevitable change. The issue comes when the American citizens, whose money is funding the motive of the issue, are not being compensated or, at least, educated to transform their now obsolete trade skills into more modern abilities to maintain value in the company or field. Economist Mark Paul argues in his publication, “Don’t Fear the Robots,” that unlike the industrial revolution in the 20th century, from agriculture to an industrial one, these workers have worked with or next to robots (Paul 2018). Even though they might not have the

skills yet to fully understand them, Mr. Paul believes that companies must help their employees by educating them with the necessary skills to help them with the transition, "we just need policies in place to ensure that workers don't bear the burden of transition." As expected, the numbers of predicted unemployment are high due to the lack of US spending on programs that help workers with economic transitions. The MIT Technology Review provides a useful graph that compares U.S. spending to other countries using the data reported by the White House. Other countries like France (0.99 GPD), Germany (0.66 GPD), and Korea (0.45 GDP) are well above the U.S. with only 0.11 percent of GDP as of 2014 (Rotman 2017). The only few initiatives date back to the 1960s, but they are too piecemeal to take on a broad labor-force disruption like automation (Muro 2017).

Research Question and Methods

This paper will analyze the impact of automation on different industries. The STS topic will give an overview of the problem and how automation can affect those that work in the manufacturing industry as well as the U.S. economy. Similarly, the technical topic will provide a specific example of how automation can impact the music industry by designing a self-playing pipe organ. Although both of these are related through automation, their focus is completely different since they look to answer two different questions. The STS paper's main focus is to analyze the following, how can the United States provide a socially responsible response to automation? This topic will mostly focus on the manufacturing industry, its employees, and the US economy. This question is important because automation is an inevitable change, and the US must adapt in order to protect its citizens and economy. The methodology to analyze this question will be through literature. This paper will dive into research papers, studies, and conferences, which will give the perspective of businesses, economists, and engineers.

Additionally, it will compare the measures that these corporations have already taken with more comprehensive approaches to automation such as the Nokia's Bridge Program case study. The technical analysis will try to answer the following question, how can we educate children automation mechanisms through a musical project? The end product of the pipe organ will be donated to the discovery museum in Charlottesville, Virginia, where children will be able to see it play their favorite songs without the need for an organist. This project will also display the power of the 3D printer machine, as it will be able to reinvent the way pipe organs work. This project aims to educate the public, and especially children, about automation so they can adapt to the pace of technological change from an early age.

Conclusion

No one actually knows how AI and advanced automation will affect future job opportunities, but the predictions are not positive for those associates in manufacturing industry. In fact, they are not positive for any worker in an industry that can be easily automated because the US government is not providing enough support in the this technological transition. For this reason, it is important to shine a light on these issues that the U.S. is facing and try to come up with socially responsible solutions. This thesis will aim to provide context and analysis to the importance of these social factors as well as structured solutions and alternatives from an ethical framework, while the technical project will provide a hands on approach to solve the education problem of automation.

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