Prospectus

Pancake Printer
(Technical Topic)

Effects of Automation in Amazon Warehouses
(STS Topic)

By

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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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Introduction

As technology advances and becomes further ingrained within our society, its effects are unmistakable in all areas of civilization. Technology can solve problems, provide entertainment, create new careers, and transform existing jobs. Yet, as with any form of large-scale change, the potential for harm can be just as large as the potential for improvement. It can be a major challenge to determine areas for growth in burgeoning technologies, all the while identifying the possible associated ethical challenges in order to mitigate negative side effects. This Prospectus will address both of these challenges in an attempt to balance technological growth in automated fields with the potential moral consequences of such advancements.

One field which has been of major interest recently is additive manufacturing. Additive manufacturing is defined as "the process of producing parts through the deposition of material in a layer-by-layer fashion" (Abdulhameed et al., 2019). This manufacturing process contrasts the common practices of subtractive and joining technology, and it provides benefits such as adapting easily to frequent design changes and the ability to produce highly complex designs at impressive speeds (Abdulhameed et al., 2019). Industrial 3D printing has gone mainstream, surpassing simple at-home hobbyist usages. A survey of decision-makers responsible for manufacturing companies with more than $500 million in annual revenue found that 45% of respondents had printed a minimum of 50,000 parts in 2020 (Dimensional Research, 2021).

Despite the surge of the 3D printing field, there is significant, underutilized room for growth in the at-home additive manufacturing market. While 3D printers are surely more ubiquitous than they once were, the International Data Corporation says that the consumer segment "has clearly not materialized as many had predicted" (Mearian, 2016). Barriers such as the skill level required to operate 3D printers as well as lack of non-traditional home-use additive manufacturing options which utilize materials other than plastic are limiting 3D printing from reaching its full market potential, especially in consumer spaces.

Furthermore, since 3D printing achieves the increasingly automated production of useful tools and materials, this can certainly bring up problems regarding its effects on the job market and the people previously responsible for such work. In order to further investigate the possible effects of such advancements, it can be helpful to analyze real-world cases which are relevant to automation. By considering the effects of Amazon’s 2012 acquisition of Kiva Robotics, which jump-started their warehouses’ automation, I endeavor to better understand potential benefits as well as detriments of such actions (Guizzo, 2012).

In order to bring about the best effects to our society with these emerging technologies, it becomes necessary to make intentional ethical decisions regarding the commercialization and industrialization of such devices. The technical project analyzes the current market for additive manufacturing devices and introduces a simple-to-use pancake printing device which fills a gap in the existing at-home 3D printer market. Meanwhile, the STS project takes a step back and examines the social effects of such technological advancements which can affect and replace human jobs through a case study of automation within Amazon warehouses, viewed through Actor-Network Theory (Cressman, 2009). In conjunction, these projects will work to better identify how to advance technical fields such as automation in ways which are useful as well as ethical.

Technical Project

As investigated, 3D printing is becoming increasingly ubiquitous in today’s world, and its applications are becoming progressively more specialized to suit the needs of various fields. Revolutionary applications of additive manufacturing are in development, many which expand into the usage of non-traditional printing materials. For example, engineers are producing devices which can address medical issues by 3D printing biomaterials such as soft tissues, hard tissues, and organs (Kholgh Eshkalak et al., 2020). Clearly, the continued development of additive manufacturing devices has the power to transform impactful fields of work as well as affect people's daily lives as 3D printers begin populating homes and workplaces.

Yet, these highly specialized additive manufacturing devices are often expensive, owned by researchers or large companies, and are far from commercialization (Kholgh Eshkalak et al., 2020). Furthermore, the average 3D printer, even commercialized versions, are still targeted towards those with pre-existing understanding of computer-aided design and the technical specifics required to create 3D printed models. Most industrial and commercial printers require people with special skills to operate them (Hossain et al., 2020). The requirement of skilled supervision for these devices creates challenges for the continued success and integration of 3D printing both commercially and in industries which usually rely on low-skill workers (Hossain et al., 2020).

As a result of the lack of focus on creating easy-to-use 3D printing, the market for at-home printers remains relatively small compared to additive manufacturing market as a whole. International Data Corporation found that the sub-$1000 3D printer segment is growing slower than every other category of consumer-type 3D printer due to lack of demand, indicating that affordable 3D printers have not yet found the sweet spot in price and usability that would allow them to be a home staple (Mearian, 2016). Leaders in the field, such as Terry Wohlers, president of an additive manufacturing consulting firm, hypothesize that the average user doesn't find the difficulty of interfacing with such a complicated device worth their effort (Mearian, 2016). There exists a largely untapped market for commercialized 3D printers as well as additive manufacturing devices which utilize non-traditional materials, especially in homes and low-skill work environments, because there has not been a focus on transforming the current standard for 3D printers.

The development of this technical capstone project takes into consideration these observations of the current state of the additive manufacturing industry and aims to create a product which fill this gap neglected by other players in the industry. The proposed technical project is an automated pancake art printer which is intentionally designed for increased usability by the average person. In doing so, this project begins to explore the concept of specialized additive manufacturing technology using non-traditional materials intended for use in the household and low-skilled business space. The pancake printer's ease-of-use aims to set the standard for other developments in the field so that future innovations are not limited to the super-rich and educated.

The pancake printer combines a range of topics covered in Electrical and Computer Engineering coursework in order to achieve a comprehensive, artistic cooking process. The process begins with a user uploading an image to a mobile application, where it is then communicated wirelessly to the printing device. The image is processed with computer vision into line art, and then the simplified art is converted into a custom instruction set tailored for usage with the physical components of the machine. A 2D rails system with an attached batter dispenser is placed over a griddle, and the motors follow the instruction set in order to dispense batter into precise detailing. The highly contrasted edges will darken onto the griddle before the background of the pancake is filled in, creating a full pancake complete with shaded detailing. This device achieves what is usually an upwards building of material by 3D printers by instead allowing the heat over time to create color dimensions. With respect to usability, the pumping mechanism is easily cleaned by running water and cleaner through the pump system, and the application is easily accessible from any mobile device. Evidently, the pancake printer exists as a comprehensive cumulation of the ECE curriculum and addresses aspects of the commercialized 3D printing market which are mostly overlooked, such as ease of use for non-technical users.

The team will use a modular methodology and will initially develop fully-functional, independent sections of the project in order to in encourage parallel progress as well as increase testability of the design. The team will obtain most of the prerequisite information to design the pancake printer from their Computer Engineering curriculum, including skills learned in Advanced Software Development, Machine Learning, Algorithms, ECE Fundamentals Series, and Embedded Computing and Robotics. Research relating to similar additive manufacturing devices and image processing endeavors will be conducted online. In order to demonstrate the ease-of-use of the device, users from various demographics with different levels of technical skill will be invited to connect their own smartphone to the application and upload images to the printer wirelessly during the end-of-semester Capstone Final Demonstrations; any user-experience complications can be noted and addressed during this time.

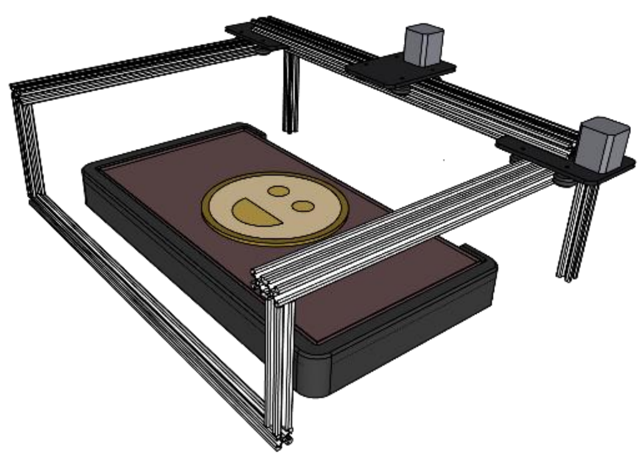

Figure 1: Computer-Aided Design of the 2D Rail Setup with Batter Dispenser over Griddle

STS Project

Since its start in 1994, Amazon.com has continuously pushed to find innovative ways to distribute merchandise, allowing them to expand into the largest retail company worldwide (Labor et al., 2020). In 2012, Amazon took new steps to further increase distribution speed and internal productivity by purchasing Kiva Systems for $775 million (Guizzo, 2012). Kiva Systems, now rebranded as Amazon Robotics, had created a disruptive technological system of mobile warehouse robots. The Kiva system is capable of deploying quickly and accurately into any warehouse setting (Mountz, 2012) and uses drive units to lift and carry shelves to workers, decreasing time spent by the workers walking around significantly (Labor et al., 2020). This acquisition was Amazon's first large step towards automation, but they have continued to invest in related technologies, deploying several types of autonomous robots. As a result, Amazon has seen great success, growing by 700,000 employees and starting hundreds of new fulfilment centers since their initial acquisition of Kiva Systems, all of which are largescale endeavors supported by automation (Labor et al., 2020). Amazon's market value also began rising sharply soon after the acquisition, starting 2012 valued at around $83B and surging to over $1700B by the end of 2021 (*Amazon Market Cap* 2021).

Evidently, the current view of the retail giant's business model and financial standing is of unmatched excellence and mindboggling growth. Yet, upon closer inspection, there exist current and future liabilities within the system. Amazon has become a staple employer in the US in many fields and skill levels, but these massive shifts to automation threaten the future of unskilled jobs within Amazon. While warehouse robots are traditionally built to work in conjunction with human employees, the retailer is working to further automate human actions. A new robot that can mimic humans by packing boxes has started to be deployed in warehouses, removing about 12 workers per newly integrated robot (Dastin, 2019). Perhaps even more concerning than the decrease in job availability is the resultant decrease in warehouse workers' safety. The serious injury rate in a warehouse in California quadrupled over three years after the introduction of automation, reportedly because the workers struggle to keep up with the speed of the robots (Evans, 2019). By neglecting to consider the blatant drawbacks of Amazon's current business model alongside its successes, it is impossible to develop a complete understanding of the sacrifices necessary to reach such extreme levels of success. With proper scrutiny, a more nuanced view of the system can be developed that allows for better predictions of the current health, ethical profile, and longevity of the company.

I argue Amazon's continued focus and investment in automation has led to the current and projected financial success of the organization, but Amazon's lack of regard for various factors such as worker safety and wellbeing as it implements these technologies and leads other companies to follow are resulting in eventual job loss and damaging worker conditions. Actor-Network theory determines a heterogeneous network composed of human and non-human actors which is constructed by a network builder in order to achieve a certain goal (Cressman, 2009). I will apply Actor-Network theory to the Amazon network, specifically centered around its warehousing operations, and I will explain how the current state of this system was built by Amazon. Furthermore, I will analyze the actors that have contributed to the network's success so far, highlight actors who are exploited by the network, and identify the actors who have the power to mitigate such inequities. In order to accomplish my investigation, I will evaluate data concerning Amazon's successes, assess employment numbers and conditions as a result of specific actions taken by Amazon, and research the motivations of powerful actors whose decisions have contributed to the network's successes and vulnerabilities.

Conclusion

With every major stride in technology, there exists a great risk for wide-spread harm. I endeavor to better understand the question: “What are the best steps we can take to improve upon current additive manufacturing technologies in a way that advances the field of automation without disadvantaging any demographic?” While 3D printers are becoming increasingly mainstream, the usage of additive manufacturing devices using non-traditional materials remains largely expensive and inaccessible. Even worse, their usage is often limited to those with the technical know-how necessary to operate such machines effectively. A shift which prioritizes the needs of a non-technical consumer is necessary for the continued democratization of these devices. The pancake printer makes strides towards addressing the need for affordable, commercialized, non-traditional printing devices with a focus on simplified usability features. It achieves this by introducing additive manufacturing to the culinary field, both for personal and commercial use, and it includes various design features which render it practical for use by all kinds of people.

Still, when studying any emerging technology, it is absolutely essential to consider all possible applications, both positive and negative. In the case of any automated field, the risk is run of replacing human jobs or worsening working conditions. Amazon’s automation of their warehouses serves as an effective example, bringing to light multiple possible consequences through analysis of each player in this complex system. Since no technological advancement exists in a vacuum and will certainly have massive effects on people, it is essential to consider all associated actors so negative consequences may be predicted and minimized.

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