Comparison of Automation and Manual Labor Jobs

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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

Automation continues to change the way we work by allowing workers to accomplish tasks quicker and more efficiently. However, as the capabilities of automation technology advances, there is growing concern about job security in the workforce. A survey conducted in 2018 found that more than half of respondents felt that "in the next 50 years, robots and computers will do much of the work currently done by humans." (Emerald Insight, 2018). Evidently, advances in automation have left many workers worried that their jobs could soon become obsolete. This is further supported by studies that attempt to forecast the potential number of jobs displaced by automation in the future. For example, in a McKinsey & Company (2017) study, they estimate levels of impact based on various adoption rates of automation technologies. In the worst case, they estimate 800 million jobs could be displaced by 2030. An Oxford University (2017) study states that jobs that perform routine tasks are at higher risk of automation, resulting in an estimated 47% of US employment at risk. Though estimated numbers can be controversial and vary significantly (Autor, 2015), a non-trivial share of the workforce faces the risk of displacement. As a result, it is critical to understand the consequences on job security, the characteristics of jobs that are the most susceptible, and ways to mitigate the impact.

As far back as the Industrial Revolution, automation has been intertwined with human history and work. Using machines to perform tasks done by hand was a fundamental shift in the way work is done. The number of jobs in farming is an example of an industry impacted by mechanical automation. The Bureau of Labor Statistics reports that during the decades of the 1960s and 1970s, the agricultural sector saw a reduction of 1.7 million and 2.0 million jobs, respectively (Daly, 1981). Automation has continued to evolve and integrate into society to the point where, according to a report by the International Federation of Robots (2021), the global

average robot density in the manufacturing industry nearly doubled between 2015 and 2019. As a result, the increasing prevalence of automation has pushed workers to focus on highly specialized jobs that have characteristics that are less susceptible to automation (Frey & Osborne, 2017). Software engineering serves as an example of a job that benefits from automation.

Software engineering is a highly specialized job that benefits from automation technology by augmenting workers to increase efficiency and reduce cognitive load, while automation in jobs like manufacturing work to replace workers, and face displacement with little opportunity to upskill. Current relevant literature discusses various attempts to quantify the risk of automation on the job security of workers. Additionally, many studies identify qualities and characteristics of jobs that are automation-resistant, namely jobs that require interpersonal skills and creative ideas. This paper will find research articles that focus on the effects of automation on various social groups. An example of this is existing legislation or legal texts that attempt to analyze or regulate the effects of automation. Given the recent trends in AI automation and the subsequent churn it is causing in perceived job security and corporations, scientific media/journal articles within the past year about the effects of these advancements on more specialized jobs will also be discussed. By analyzing the gathered sources, this paper will attempt to show why software engineering is a specialized job that benefits from automation.

Literature review

A common perception among employed workers is that there exist specific characteristics of jobs that are automation resistant. From a telephone survey of 1,100 employed, researchers found that creativity is important regarding an individual's perception of job security, while a repetitive job is negatively associated with it. Specifically, respondents who reported repetitive jobs were 6.5% less likely to say they are not at all concerned about automation. (Coupe, 2019). Another survey conducted in 2020 found that individuals employed in jobs with manual labor or physical tasks had a negative perception of the impact of automation while jobs that required interpersonal skills, like managerial jobs, and highly technical skills, like data analysis, had more positive views. Another finding is that younger, more technologically savvy, employees had more positive attitudes as well (Dodel, 2020).

To further support this perception, many studies attempt to broadly estimate the number of jobs that are at risk of exposure of being automated. For example, a 2017 report from McKinsey & Company estimates that 50% of work activities are considered at risk of being automated. They estimate that by 2030, at the fastest forecasted rate of automation adoption, 800 million workers could be displaced. Additionally, literature supports that jobs requiring creative intelligence and interpersonal skills are less susceptible to automation. Jobs within sciences and engineering fall within this category (Frey & Osborne, 2017). There also exists literature that examines the aggregate employment rates and finds that previous nineteenth and twentieth-century waves of automation did not actually result in net job loss. They argue that many similar assessments neglect that tasks can vary significantly within the same occupation while not accounting for general problem-solving and social skills, as a result, jobs like book-keeping, accounting, and auditing have a high risk of automation. However, after considering differences

across tasks in workplaces within occupations, they estimate that the number of workers that face a risk greater than 70%, actually falls to 9% from 38% (Arntz, 2017). Evidently, the exposure of jobs at risk of automation can vary based on a variety of variables and factors, however, there is some consensus that jobs that require certain human characteristics, like problem-solving, creativity, and interpersonal skills, are much more resistant to being automated.

A report delivered from a joint study between the United States and the European Union during the US-EU Trade and Technology Council culminated from the effort to assess the impact of artificial intelligence on the workforce. They state the "promising and wide-reaching potential" for AI to benefit "productivity, growth, inequality, market power, innovation, and employment" (The White House, 2021, p.9). However, they recognize the risk that excessive automation brings to workers as, "there is no guarantee that the current pace of the development of AI tools will achieve the socially optimal mix of automation and augmentation of tasks" (The White House, 2021, p.9). The report goes on to present an agenda for governments to guide artificial intelligence towards a positive direction, with recommendations for an investment in training services for workers disrupted by artificial intelligence, encouraging the development of artificial intelligence that augments workers both in private and public firms, and creating government regulatory agencies to regulate artificial intelligence systems.

As a lens to analyze this sociotechnical issue, Actor Network Theory will be used to describe the various relationships between actors in the network of automation, workers, government, and businesses, while evidence and analysis will be used to discuss why some of these relationships occur and affect each other. ANT is a strong contender to analyze automation because it models actors, both human and non-human, as entities that can exert influence on a network. This is useful in avoiding simplistic "black-box" depictions of technical topics like

automation and artificial intelligence. It is also useful to analyze shifting power dynamics in a network. As a result, the analysis will attempt to dissect the various capabilities that are realistic for these technologies by discussing the concepts they are built on.

Methods

To gather data to support the argument, I aggregated secondary sources of research articles that focus on the effects of automation on various social groups. Other primary sources I gathered are existing legislation or legal texts that attempt to mitigate or regulate the effects of automation, such as government bodies, like the White House, and other organizations focused on employment, like the Bureau of Labor Statistics. Given the recent trends in AI automation and the subsequent churn it is causing in perceived job security and corporations, this paper will look at various capabilities of AI within the past year to consider effects of these advancements on specialized jobs.

Analysis

Automation works to replace workers in manual labor jobs like manufacturing and farming. Machines and robotics can perform tasks more efficiently and accurately, while requiring no benefits or safety, like their human counterparts. In manufacturing, robots can assemble products on an assembly line. According to the International Federation of Robots (2021), 28% of all robotic machine installations occur in the automotive industry.. In these industries, automation reduces human intervention to handling machine maintenance and malfunctions (Bainbridge, 1982); humans work to complement automated machinery. In the context of Actor Network Theory, a network within a manufacturing plant can consist of workers, robotic machinery, and the business needs of the plant. With the introduction of

automated machinery into the network, workers lose power as they are delegated to oversee the machines or other roles that are complementary to automation, as opposed to being the main actors that output products or value for the company. Consequentially, the power dynamic shifts to automated machinery, as they directly displace human workers by reducing demand for them. Businesses are incentivized to introduce automation as it allows them to set broader goals for efficiency, productivity, and output, allowing businesses to reach economies of scale (Kenton, James, & Velasquez, 2023). As a result, businesses gain power within the network by introducing automation as they no longer are dependent on manual labor

In contrast, automation serves to augment workers in software engineering. For example, software engineers utilize automation to run test suites that determine the correctness of defined behavior in code. These benefits are compounded as developers must no longer manually test previously tested code with new code changes. Even if code for a function is completely rewritten, the corresponding tests do not have to be rewritten, as the defined behavior of a function should not change. CI/CD (continuous integration/continuous deliver) is a methodology used by DevOps engineers that uses automation to accelerate the delivery of code in a way that is reliable and secure (Redhat, 2022). Continuous integration is automating the process of integrating new code changes in a central repository in a way that reduces conflicts in code and ensures correctness. Continuous delivery automates the release of code changes to production and customers. In both cases, they reduce development time and time to market. By automating redundant processes that must be done by developers, it reduces the effort they expend on these tasks, allowing them to focus on problem-solving and collaboration.

The gains in efficiency that automation provides to software engineers do not reduce the number of engineers needed, unlike in manufacturing jobs. Though it reduces effort spent on

redundant tasks, automation tooling requires manual configuration by users with specialized technical expertise, such as DevOps engineers or test engineers. Efforts to utilize automation are a long-term investment towards better reliability and efficiency that require a short-term time investment to configure; a constant balancing act between improving processes and meeting deadlines. Automation in software development can be seen to increase the demand for workers with the necessary expertise. A report by SentinelOne (2017) finds that between 2014 and 2017, the percentage of respondents of a survey employed in DevOps doubled. From 2015 to 2016, "the role of DevOps Engineer has seen a 225% jump in postings on Indeed" (SentinelOne, 2017). Contrary to manufacturing jobs, automation does not directly produce the main deliverables of software engineering, which are to design, implement, and deploy software systems,

In a case study of a growing software startup, automation was used to help manage organizational processes and reduce engineering burden. During periods of focus on fast growth and revenue generation, tasks that were automated allowed managers to continually reconfigure the usage of developer resources to perform tasks that had yet to be automated or were unable to be automated. (Shestakosky, 2017). Recalling Actor Network Theory, this situation describes a mutually beneficial network localized within a company. Specifically, automation takes the form scripted processes and tests configured by developers, for developers, to reduce cognitive load on developers by minimizing the redundant work of maintaining similar development environments and running tests. Developers act on automated tooling by manually configuring and maintaining it, while the automation tooling act on the developers to speed up their work. This augmentation allows managers to lead their developers to efficiently complete their other non-automatable tasks. Developers work in tandem with automation, which does not decrease a

manager's dependence on them. As a result, the introduction of automation does not cause a shift in the power dynamic in this network.

Despite the seemingly complementary relationship between the current state of automation and a specialized industry like software engineering, it can be argued that advancements in machine learning in the form of artificial neural networks (ANN) can disrupt previously believed notions of automation-resistant jobs that require interpersonal skills and creativity. ANNs are designed to simulate the structure and function of the human brain, they consist of interconnected nodes that process and transmit information, and they are trained using large amounts of data to recognize patterns and make predictions (IBM, 2021) and can be used to develop models that can generate music, art, and code. OpenAI's DALL-E2 can generate art and images from text-based prompts (OpenAI, 2022). In the customer service industry, AI-powered chatbots and virtual assistants have become increasingly sophisticated and are now capable of handling complex customer interactions (Bushnell, 2021). Previous forms of automation have been limited by physical and material restrictions, however, the ability to generate relatively novel deliverables, like music, art, and code show a shifting of power to automation technologies. In the context of Actor Network Theory, workers have less ability and need to act on automation technology to direct and maintain it, while automation has gained new power to act by directly accomplishing non-routine tasks that were previously done by human workers. As artificial intelligence continues to advance, its adoption will depend less on its capabilities to deliver and will depend more towards social and business adoption.

Regardless, what characteristics of software engineering as a discipline continue to create a mutually beneficial relationship with automation? While artificial intelligence can automate some aspects of software engineering, such programming, maintenance, and debugging, the

scope of software engineering is not just limited to programming. Software engineers are constantly designing, analyzing, and implementing software systems. This requires constant communication and feedback with stakeholders to elicit requirements, as well as collaboration with other software engineers to split up tasks and share domain knowledge. Legacy decisions in codebases are made because of past business needs and deadlines; this history needs to be understood to make informed decisions in the future. Even with the current capabilities of artificial intelligence, the need for creative problem solving and interpersonal skills allows automation to complement software engineers, instead of replacing them.

Conclusion

Software engineering is an industry that benefits from automation, as its emphasis on creative problem-solving and interpersonal skills highlights its resistance to automation. These are characteristics that will likely grow in importance for workers as manual labor jobs are displaced by automation, especially as the capabilities of artificial intelligence advance. Since businesses are incentivized to adopt automation to increase revenue, efficiency, and reduce labor costs, policies must be implemented that mitigate and manage the detrimental effects of automation on job security. Policies that continue the trend of previous waves of automation to reduce menial work and allow workers to specialize would be ideal. As a result, incentivizing the creation of AI automation that augments workers would prove mutually beneficial. Another policy would be to develop governmental bodies that regulate and ensure AI systems perform tasks in a way that is unbiased and transparent for workers.

Despite the future unknown capability of artificial intelligence to generate works of art and music, these face the issue of cultural adoption. In 1935, when technology such as the printing press became widely used, Walter Benjamin proposed the idea that mechanical

reproduction devalues the "aura" of art. He states that, "Even the most perfect reproduction of a work of art is lacking in one element: its presence in time and space, its unique existence at the place where it happens to be" (Benjamin, 1935). Using this framework, work from human artists and musicians are unlikely to disappear simply due to its authenticity associated with human work. This can be seen in the demand for the number of personal, family-owned wineries and breweries, which in the US, has grown from 110 in 1975 to 4,269 in 2015, or Etsy, an online marketplace of products produced solely by individuals (Plumer et al., 2016).

Workers, researchers, policymakers, and businesses likely have a vested interest in automation research. Workers should understand how automation could affect their job security. Researchers and engineers developing automation technology should consider the implications of their work replacing individuals and ensuring automated processes are unbiased and impartial. Policymakers could use this information to develop policies that address and mitigate the risks and benefits respectively within the job market, as well as other social initiatives. Business owners would likely be interested in the benefits of automation to further streamline and reduce the costs of their operations while better understanding the consequences for their employees.

Future work should look at how automation affects software engineering in a variety of different types of industry, such as software engineering in healthcare, retail, or financial services. More broadly, future work should look at the capabilities of artificial intelligence automation purely from a technical perspective. It should consider the scope of it and how it applies to various jobs. Additionally, further research should consider the ethical implications of artificial intelligence, regarding how datasets may be trained on other people's work, or how biases in artificial intelligence decision making. As artificial intelligence advances, and

governments, businesses, and workers react, we will be at the forefront of exciting new capabilities.

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