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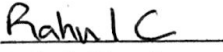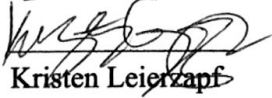
December 6th, 2019

Dear Professor Owen,

Enclosed is our report on automation, entitled An Analysis on Automation and Effect on Employment. Automation is growing rapidly, and it will become much more prevalent. Concern is growing among workers, and it is important we educate them on the effects of automation.
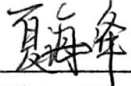
This report first discusses the background of automation in manufacturing, how automation is being used right now in industry, and the public's opinion on automation. We then discuss the benefits of automation, and some of the potential drawbacks. We also further discuss the relationship between automation and employers and employees. Finally, we examine a specific example of automation, and how it helps the industry. We then finish the report with some recommendations for further information about automation, and how we can help the world adapt to automation better.
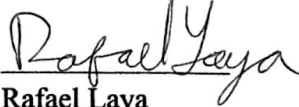
Our group strongly believes that the benefits of automation outweigh the drawbacks, and it is important that the world is prepared for the incoming automation revolution. If you have any comments, questions, or concerns, please do not hesitate to contact any of the members of Engineers for Ethical Automation.

Sincerely,
Engineers for Ethical Automation

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An Analysis of Modern Automation in Manufacturing

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Final Report

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Executive Summary

Over 65% of the population in the US believes that robots and automation will take human jobs eventually. However, it has been shown repeatedly that automation actually improves the economy and job prospects rather than slowing it down or depleting it, and automation is actually inversely proportional to unemployment.

Automation makes things safer, cheaper, more efficient, and actually generates more jobs than it destroys. However, the growing discontent over automation taking worker jobs is concerning, so it is imperative that we educate the public on automation, and prepare the work force to be able to adapt to automation and new technology. The ethical impacts of automation includes who it impacts the most, and who it benefits as well as harms.

This paper examines the history of automation in manufacturing, the current uses of automation, and how automation will change in the future. The paper also goes in depth about the relationship between automation and employers/employees as well as the challenges and benefits of automation in the workforce. It also includes recommendations for adapting to the automation revolution.

Introduction

Across the United States, there are headlines reading "Automation threatening 25% of jobs in the US" leading many to fear automation (Nova, 2019). Despite the sense of fear from the public, many companies continue to become more reliant on automation to stay competitive in their manufacturing processes. This is largely due to the increase in productivity, safety, and accuracy across processes.

This paper will cover the benefits of automation, currently unnoticed by the general public, and how automation will contribute greatly to the job market. Firstly, the report will discuss the history of automation and how it plays a role in the current job market. The next section will cover various stakeholders including the relationship between automation and employment as well as the impact of machine learning on the addition of automation in the workplace. Through deeper evaluation of a variety of industries, it is apparent that automation contributes to the workforce through the addition of direct and indirect jobs. The challenge will be helping employees transition within this restructured job market.

Background

Automation in Manufacturing

As time goes by, technology has been developed and updated rapidly. At the same time, manufacturing produces thousands of goods, satisfying people's needs and wants. In order to improve the efficiency of production and lower its operational expenses, automation is employed in manufacturing. "The word 'automation', in the manufacturing sense, was coined by Ford Motor Co. Vice President Delmer S. Harder in 1948." (PHC, 2016, p. 2). The most common definition of automation in manufacturing is:

> Industrial automation is the use of 'intelligent' machines in factories so that manufacturing processes can be carried out with minimal human intervention. It involves the application of various control systems to enable operating equipment to carry out on their own, with little human intervention, tasks that require speed, endurance and precision. (Cerasis_IT, 2014)

For example, the car industry uses robots in assembling and painting as shown in figure 1. Other facilities assemble equipment used in healthcare, and more complex systems use computer-driven sensors to tune up and adjust screws.
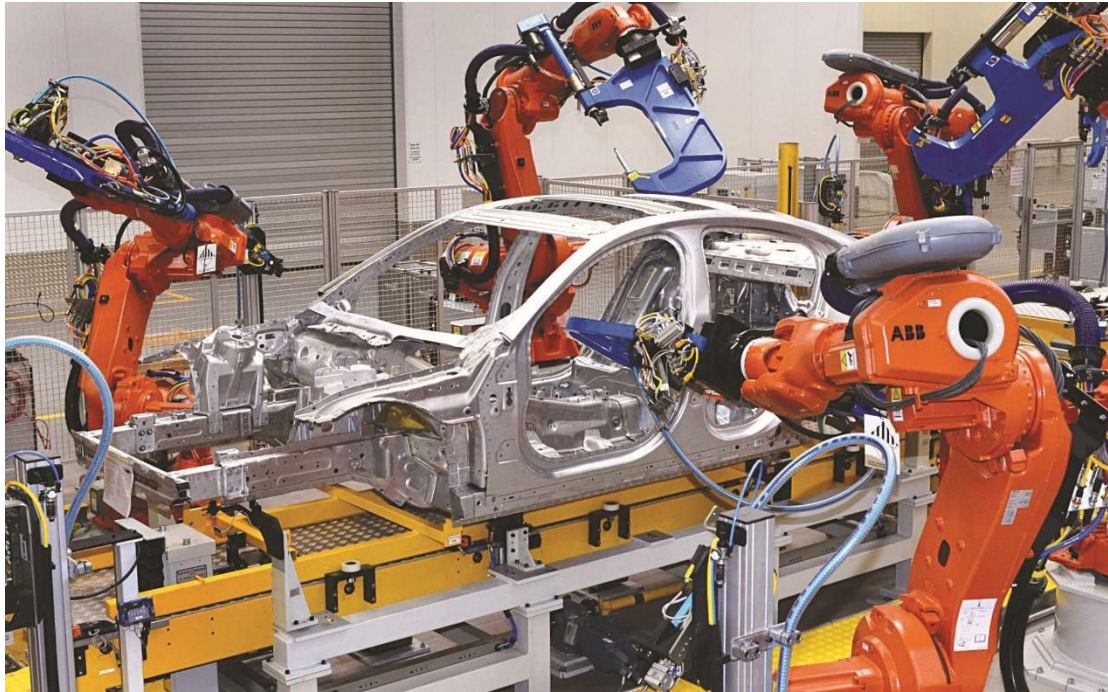
Figure 1. Robotic arms in the car industry are assembling a car frame. Adapted from Editor Team, 2017, Retrieved from https://smart.electronicsforu.com/robotics-in-manufacturing/

Furthermore, there are three types of automation used in manufacturing: fixed automation, programmable automation, and flexible automation (Groover, 2019). Fixed automation has an unchangeable configuration, which is mainly employed in high-volume and repetitive productions. Programmable automation allows to be changed over and coded to manufacture batches of variety of products. Flexible automation is similar to programmable automation, but it is limited in that its programming processes are done offline. Flexible automation can process and manufacture different products in a single line. Most of the claims in this report are valid for all kinds of automation, but it focuses on programmable automation since it adds more flexibility, it is what most authors refer to, and it is where the future is headed.

History of Automation in Manufacturing

Today, we are at "Industry 4.0", which is a concept introduced by the German government in 2011. (Bahrin, Othman, Azli,, & Talib, 2016, p. 3) There are four industrial revolutions marked in human history. The first revolution was driven by the invention of steam-powered machines and water-powered machines between 1760 and 1820. The second one was the occurrences of railroad networks and the telegraph between 1870 and 1914. The third revolution was the digital revolution which brought electronics and modern technology to the world. Finally, the industry today is having its fourth revolution, involving "the rise of autonomous robots, contemporary automation, cyber-physical systems, the internet of things, the internet of services, and so on."

(Bahrin, Othman, Azli,, & Talib, 2016, p. 3) In a word, automation is one of the main drivers, which leads the revolution in contemporary industry.

Industry automation can be traced far back in time when there were machines powered by mechanical, hydraulic, pneumatic, and some other means, increasing work efficiency and precision, for example, "the lathe," which was invented in 1722 and referred to as "the mother of machine tools" (Phc, 2016) and is shown in figure 2 to contrast with modern machines.

Figure 2. The Lathe. Adapted from PHC, 2016, Retrieved from
https://www.phcfirst.com/words-in-motion/2016/9/7/a-brief-history-of-automation/.

By the 1800's, the industries were aspiring to operate mass productions, which provided an opportunity for automation to have a role in manufacturing. Later, "factory productivity rapidly increased due to electricity in the 1920s and by the 1930s the automotive industry was leading the charge in industrial automation." (Phc, 2016) By the 1980s, the idea, "lights-out"came up, which says the lights could be turned off, and everything could be given to the automatic machines inside factories. Today, "lights-out" still on its way to be accomplished although it is not fully accomplished yet. More and more advanced technologies related to computer and internet have been created and employed in manufacturing facilities, such as sensors and programmable robots mentioned before. Therefore, the manufacturing industry is experiencing an increase in the use of robots.

Current State of Automation in the Industry

As explained in the previous section, "Lights-out" is an ideal concept that human beings have been trying to fulfill throughout history. In contemporary manufacturing factories, the use of automation is improved with more and more advanced technologies, although "lights-out" is still a concept rather than a reality. Nevertheless, automation is currently widely used and is vastly exploited in massive production lines, ensuring product's quality and increasing manufacturing capability in terms of output quantity and the products that we can develop. Not limited to that, as software and computer technologies are rapidly developed, automation starts to be involved deeper into manufacturing operations with some level of flexibility, such as robots that are programmable and can perform multiple tasks. Following this trend, each year will bring greater capability for automation in manufacturing.

Figure 3. Robots packaging sausages. Reprinted from "Clever Handling: Alyson Magee examines how robotics can enable Meat firms to achieve greater efficiency and sustainability Across their businesses," by A. Magee, 2015, Meat Trades Journal, p. 18.

Figure 4. Members of the US Air Force posing for the Defense Robotic Surgical Education program next to a surgical robot. Reprinted from *Military Simulation & Training Magazine,* 2019, Retrieved from https://militarysimulaton.training/technology/ robotic-surgery-milestone/.

Figure 5. Robotic arms in a factory. Reprinted from Unsplash, By D. Leveque, 2019, Retrieved from https://unsplash.com/photos/GpNOhig3LSU

Figure 6. Welding robot. Reprinted from Robotics Online Blog, by Robotics Online Marketing Team, 2017, Retrieved from https://www.robotics.org/blog-article.cfm/Robotic-welding-Improving-the-Performance-of-Your-Automated-Welding-Processes/61.

Figure 7. Robot assembly line in car factory. Reprinted from 1234f, by K. Jirasukhanont, n.d., Retrieved from https://unsplash.com/photos/GpNOhig3LSU

Figure 8. Asbestos removal machine. Reprinted from "A framework of indicators for assessing construction automation and robotics in the sustainability context," by Takenaka Corporation, Journal of Cleaner Production, 182, p. 3.

Automation has been exploited greatly in many traditional manufacturing fields. Robots are generally assigned to perform simple and repetitive work. The range of tasks that robots do in manufacturing are very diverse, meeting the needs and wants of the consumers. Robots are so widely used that it would not be reasonable to make an extensive list. However, the figures above exemplify some of the most common uses of robots. Robots are commonly used for packaging products in the food industry (Figure 3), for surgical procedures in medicine (Figure 4), as general robotic arms in any industry (Figure 5), for welding materials (Figure 6), assembling cars in the automotive industry (Figure 7), and for removing toxic materials such as asbestos in buildings (Figure 8). In a single sentence, automation in manufacturing has already had a profound impact on every human being's daily life, which is one reason we should care about the present topic.

Discussion

Public's Opinion on Automation.

Over decades, there have been thousands of science fictions and movies depicting the power and intelligence of robots, leaving people with an abstract impression on those robots. Naturally, living in this environment and listening to dystopian opinions tends to make people believe that highly efficient machines will steal their jobs. Let's refer to figure 9:
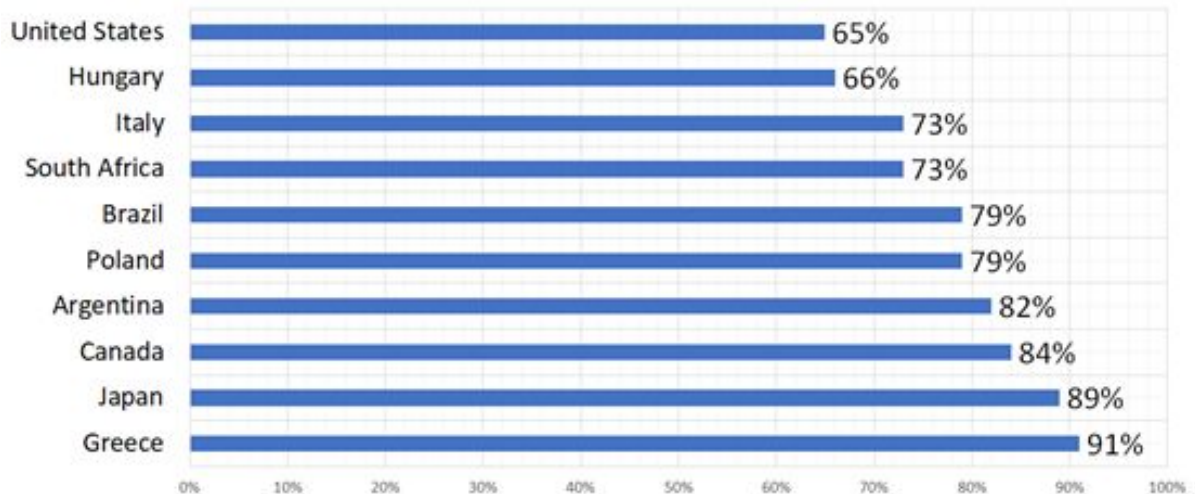
Percentage of people that believe robots will take the jobs of humans by country

Figure 9. Percentage of people that believe robots will take the jobs of humans by country. Data by Pew Research Center, adapted from The Washington Post by A. Taylo., 2018, Retrieved from https://www.washingtonpost.com/world/2018/09/13/people-around-world-think-that-robots-will-soon-take-most-human-jobs-that-people-will-suffer/.

Figure 9 shows that people in many major countries all over the world believe that robots will take away jobs. In all countries that were analyzed, the results were far higher than 50%. In fact, the lowest shown is 65% in the US. The data clearly shows that people believe robots will take their jobs. Although it is normal for people to fear losing their jobs to these marvelous machines, we will show that automation in manufacturing actually creates more jobs than it destroys.

Advantages of Automation in Manufacturing

In this section, the advantages of automation in manufacturing sites will be discussed in terms of safety, efficiency and costs.

Safety

Automation improves safety in the workplace. In fact, most authors agree that automation and robotics perform the dull, dirty, and dangerous tasks that humans would rather not do, which allows factory workers to perform more meaningful work (Magee, 2015; Ogbemhe et al., 2017; Pan et al., 2018;RobotWorx, n.d.; Vargas, 2018; ; Association for Advancing Automation, 2018). Since machines replace humans in the most dull, dirty, and dangerous tasks, it is easy to see why the workplace is much safer with robots: A robot prevents a possible accident involving workers when the robot performs a dangerous task. For instance, Pan et al. (2018) explains that automated machines can prevent construction workers from falling, getting electrocuted, or getting hurt by misuse of complicated machinery. For example, consider the poultry deboning

robot shown in figure 10. If a machine is used for deboning chicken, then it is essentially preventing humans from having accidents when deboning or cutting the meat.
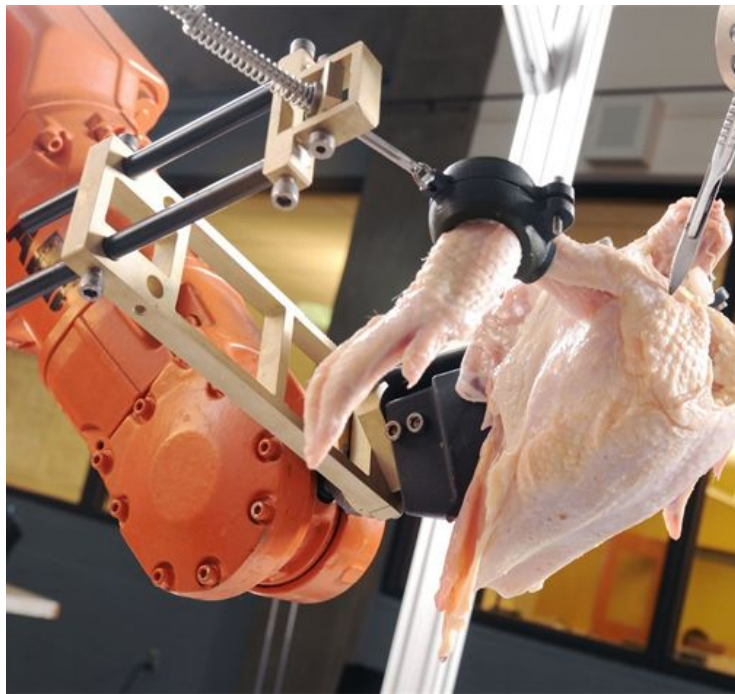
Figure 10. Deboning Poultry Robot. Reprinted from Robotworx, (n.d.), Retrieved from
https://www.robots.com/articles/deboning-poultry-with-meat-processing-automation

Although in many cases safety can mean fatalities, it can also refer to health and quality of life. Robots can do tasks that might not be dangerous but still harsh to humans (Magee, 2015). Jobs that are harsh could be lifting heavy equipment, being in uncomfortable or unergonomic positions, performing unsatisfactory tasks, or working with chemicals or fumes that will affect workers' health in the long run. Some of these adverse effects include musculoskeletal disorders or traumatic injuries and can trigger hazards such as chemical spills (Vargas, 2018). Having robots perform harsh activities allows workers to have a longer and healthier life because they are not exposed to unhealthy activities. For instance, consider the welding robot in figure 11. Welding fumes can be toxic. By having a robot weld, it is preventing humans from inhaling welding fumes. In addition, the benefits of having robots in the workplace that perform the dangerous tasks include an improved job satisfaction (Magee, 2015). By being more satisfied, the workers can also experience psychological safety.

Figure 11. Welding robot. Reprinted from *Robotics Online Blog*, by Robots Online Marketing Team, 2017, Retrieved from https://www.robotics.org/blog-article.cfm/Robotic-Welding-Improving-the-Performance-of-Your-Automated-Welding-Processes/61.

It is true that machines are not perfect and can make mistakes which pose a risk to the workers around. However, robots can help meet safety standards while being easy to program (Ogbemhe et al., 2017). As a consequence of being programmable, robots are often updated with new safety features that improve the safety of the workplace. Automated machines will immediately follow each new safety procedure as soon as it has been implemented, while it might take weeks for workers to get accustomed to new measures, which results in a security threat. As an example, the UR15 robot has adjustable safety settings that makes the robot stop when it encounters a certain force (Clemens, 2016). In addition, robots don't forget nor have the option of ignoring safety measures like humans do, which means that they always follow all the protocols to minimize risks. It has been shown that robots can perform duties that are boring and could harm the workers (Len, 2018; Vargas, 2018). Robots don't become bored or stop paying attention; they just obey their programs. As a result, robots improve safety in the workplace.

Efficiency

Automation increases the efficiency in terms of units of output per unit of input. Since technology advances quickly, robotic solutions are now much more efficient than humans in certain areas that don't require much thinking. Magee (2015) explains that robots such as the ones shown in figure 12 bring flexibility, speed, precision and accuracy to the meat industry since they can pick and place up to 240 items per minute. In a similar manner, Clemens (2016) talks about the technical capabilities of robots designed for general-purpose applications that require speed and accuracy that easily surpass human abilities. Given that robots can be much faster than humans, it is reasonable to think that efficiency should go up at least in terms of

time-dependent resources and the resource of time itself. For instance, Clemens (2016) stated that robots speed up packaging processes which increases efficiency.

Figure 12. Robots packaging sausages. Reprinted from "Clever handling: Alyson Magee examines how robotics can enable meat firms to achieve greater efficiency and sustainability across their businesses," by A. Magee, 2015, Meat Trades Journal, p. 18.

Besides being faster, robots have a wider availability than humans. It is common knowledge that employers like robots because they work 24 hours per day (Ogbemhe et al., 2017). Working without stopping can seriously increase efficiency since there is no downtime in the factories. It has been shown that robots can monitor crop conditions to provide adaptive treatment to local areas including plant by plant in order to increase the efficiency of the overall crop (Bugmann et al., 2011). Humans can't take the time and effort to monitor plant by plant like robots could. Allowing robots to provide adaptive treatment to local areas in a big crop can make substantial improvements in the efficiency of the whole farm. Another example in the food production occurs in the milking sector. Bugmann et al. (2011) explains how milking robots provide availability twenty-four hours a day so that the cows can voluntarily be milked at any time of the day to increase yield and therefore efficiency. Again, since robots don't have to sleep like humans do, robots can provide availability to obtain more resources to increase efficiency.

Costs

The use of automated machines can reduce manufacturing costs. As recently discussed, robots are more efficient. More efficiency translates to monetary savings. For instance, automation makes manufacturing more cost-effective due to continuity since machines don't get tired (Magee, 2015; Ogbemhe, 2017). In construction, automation results in savings in labor, resource,

waste management, time, and reduction of rework (Bock & Linner, 2015 and Mahbub, 2008, as cited in Pan et al., 2018). It has been shown by Warszawski (2003) that automation brings economic value in construction because it reduces delays and labor costs (Pan et al., 2018). Robots can increase efficiency, which as a consequence reduces costly delays and labor costs per project because projects are finished earlier. Ogbemhe et al. (2017) argue that training and maintenance is cheaper for robots than human staff. Given that training is done only once when the robot is programmed as opposed to each staff, this can result in high savings. Also, robots become very cheap to maintain after they have been implemented, since all it requires to keep running is electricity and repairs. It is important to keep in mind that maintenance is very important for all machines. For example, The Robotics Online Marketing Team (2017) advertises that maintenance reduces downtime and maximizes the recovery of the investment for their robots.

It is true that robots require a high initial investment. However, the initial cost can be quickly recovered due to increased profits and reduced costs (Ogbemhe et al., 2017). Bugmann et al. (2011) claim that the investment is usually recovered in 2 years or less, after that the only cost is electricity which is 50 times cheaper than manual labor. Therefore, the initial investment is well worth because it will be recovered due to the higher efficiency and reduced costs. After that, the machine will keep running to make more profits. Machines can usually last for more than two years. A robot will usually last well beyond the point where the investment is recovered (Ogbemhe et al. 2017; Len, 2016).

Machine Learning and Automation

Growth of Machine Learning and Concern

One of the biggest aspects of automation in the future will be machine learning. Machine learning (ML) is essentially the concept that once a computer is fed enough data, it can make intelligent decisions based on the data provided, without human intervention (AiThority, 2019; Chuang, 2019; Feldman, 2016). Machine learning and artificial intelligence(AI) is a rapidly growing sector, and it is a cause of concern for many in the field, as some believe it may be lowering the number of jobs available. In the below graph, one can see how revenue of artificial intelligence is growing exponentially, and figure 13 gives evidence to the fact that AI will be all around us in the future.
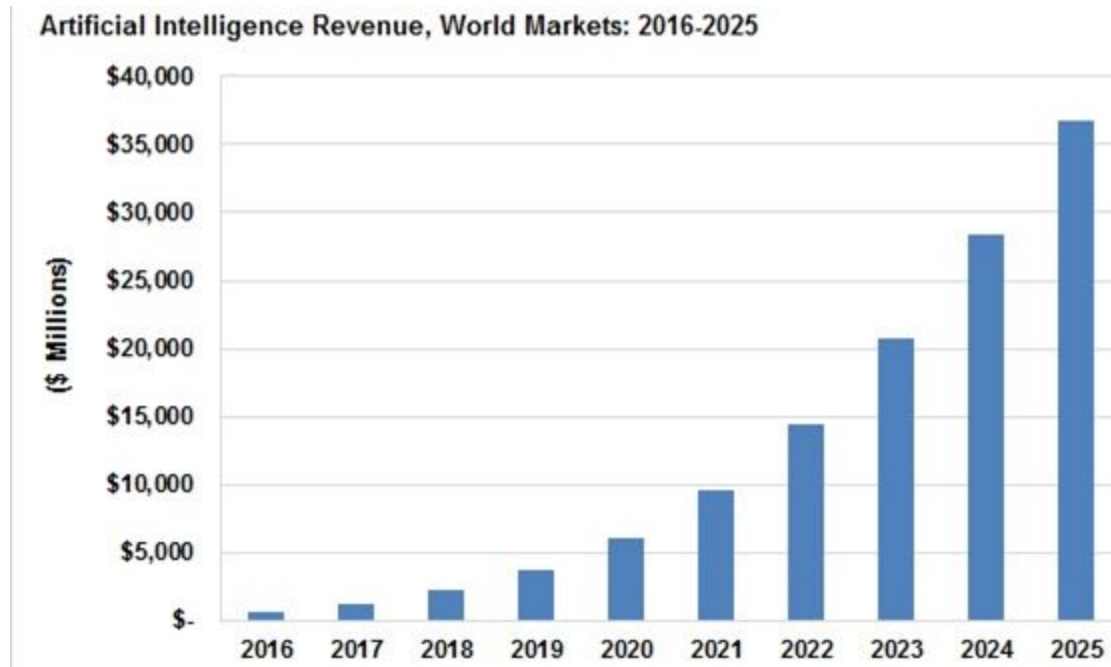
Artificial Intelligence Revenue, World Markets: 2016-2025

Figure 13. Artificial Intelligence Revenue, World Markets: 2016-2025. Adapted from "Artificial Intelligence Revenue to Reach $36.8 Billion Worldwide by 2025," by Tractica, 2016, retrieved from https://www.tractica.com/newsroom/press-releases/artificial-intelligence-revenue-to-reach-36-8-billion-worldwide-by-2025/

However, most reports actually show that machine learning and AI will not be stealing jobs, but simply changing them. This is because most machine learning is still very narrow -- meaning that models are built for specific tasks, not general tasks. Thus, machine learning will replace tasks instead of jobs, since there are so many components to any job. Most experts believe that generalized intelligence, that can perform many tasks, won't emerge in the near future, so we only need to worry about technology that can do certain tasks, instead of an entire job.

Machine Learning Augmenting Jobs

According to a study by Microsoft, more than two-thirds of business leaders believe that machine learning and artificial intelligence will augment jobs, not replace them (as cited in AiThority, 2019). Only 7% of workers that have an understanding of AI actually believe that AI will replace their jobs, further giving evidence to the idea that machine learning and AI will simply augment jobs, not replace them. The staff from AiThority supports that "[AI] saves money, supports the skilled worker, frees up time previously occupied by monotonous and tedious tasks and is ultimately a necessary step forward in the ability to meet the needs of both businesses and consumers." (AiThority, 2019, para. 9) The fact of the matter is that AI and ML can automate away the boring or dangerous parts of jobs, so that workers are free to do more complicated things.

11

Case Study

In Colorado the burger chain Good Times Burger & Frozen Custard uses AI in many ways. One of the AI's they use is called Holly. Holly is an "artificial intelligence conversation platform," which essentially means that the AI takes orders for customers. Employees repeatedly mention that it makes things go smoother, as the AI essentially gets the orders so the employees can focus on making the food. In fact, Holly improved efficiency by 10-25 percent (Chuang, 2019).

Holly doesn't forget orders, get bored, or act out. Holly lowers wait times, decreases the stress of the human employees, and does not cost nearly as much as a human replacement. This is the hope for all machine learning -- to improve efficiency, and make lives easier for their human counterparts. Notice that no jobs were taken -- they were simply augmented.

Relationship Between Automation and Employment

As it has been discussed earlier in this report, most people believe that robots will take people's jobs. However, such is not the case. In reality, automation creates more jobs than it destroys. One reason is that robots create jobs directly and indirectly. For instance, by 2011 robots had created between 4 and 6 million direct jobs and 8 to 10 million indirect jobs (Ogbemhe et al., 2017). Direct jobs follow immediately from the the of these machines, such as operators, technicians, and engineers. Indirect job covers jobs that are created because more robots are used. This could be salespeople, workers that provide resources, transportation workers, new businesses, and many others. Magee (2015) explains that robots don't take jobs, they just redistribute labour. Now, workers are more free to do more important work, rather than mindless repetitive work such as packaging. In fact, Pan et a. (2018) suggests that there is only an economic benefit to robots when they perform repetitive tasks that don't require much thinking. Thus, there is no reason to be afraid of losing jobs to robots as they will only help with mindless tasks. In fact, robots are not separated from people, instead they collaborate with the workers to make work easier (Bicchi et al., 2015; Megan, 2016). As a result, it should be expected that robots create more jobs than they displace.

With advances in technology, robots are made more accessible each year which makes it possible to source programmers, operators, technicians and other roles in-house (Len, 2016). There have been examples where workers are trained to work with machines, for instance, Magee (2017) mentions that ABB can train operators to manage their robotic systems safely and efficiently in two days. This also does not mean that engineers are less needed in manufacturing, first, they are needed to design robots. Second, they are even more needed to solve the more complex robotic problems. Magee (2015) claims that it is necessary to train technicians and to

bring more engineers to the team. Therefore, many new roles are created due to automation in manufacturing.

The forecasts also support the idea that automation creates more jobs than it destroys. The centre for the new economic and society (2018) estimates that between 2018 and 2022, robots will have displaced 75 million jobs while creating 133 million new roles. Clearly, automation creates more jobs than it displaces.

Recommendations

In considering the rapid growth across industries and the expectations of the consumer, companies must produce a quality product, and do it quickly. To stay competitive in an environment like the one currently experienced, speed and accuracy is of the most importance, leading to the increase in automation. The shift in workforce expectations is inevitable and will continue despite the general public fear. It is critical that training is in place to better prepare the public for what is in front of them.

The perceived negative impacts of automation is that it will take jobs. However, machines are incapable of performing every task a human can. A machine may take simple tasks, and while it is true that it may result in current jobs becoming obsolete, it would be an injustice to not discuss the future development of direct and indirect job opportunities connected to the world of automation. The general workforce will see a net increase in available jobs due to automation.

Additionally, automation increases the ability for a company to achieve the wants and needs of its consumers. This is because automation increases accuracy and speed of production while decreasing cost. These qualities are beneficial to both the company as a whole and to the consumer. It produces an environment that promotes skilled workers, which is the key to staying competitive in the changing job market.

It is our recommendation that companies take proactive steps to ease their employees fears. This could be done in a variety of ways, but most importantly, through the implementation of training to help their employees gain skills to contribute effectively to this new market. Automation will take repetitive tasks. It is crucial to provide employees with the background to contribute to the company as an operator, technician, or engineer, for example. While these career paths have various educational requirements, there are also many indirect jobs that will be created. These careers include sales and transportation, among others. It is the responsibility of companies to understand the value of its employees and give them the necessary training to fulfill the requirements of these new jobs.

We would like to emphasize the need for companies to take ownership over their production processes and their employees. Through proper training and care for its employees, both the company and the public will benefit as automation continues to become more prevalent across all industries.

Conclusion

The first industrial revolution saw the implementation of steam- and water-powered machines. Since then, the continued development of machinery and manufacturing processes has shown the consumer rapid change in every industry. These changes have since been categorized into four industrial revolutions with each bringing its own set of challenges and fears to the public. But through each revolution, society has benefited.

We are currently facing fears and growing pains, however we have historically seen the benefit of reevaluating our processes and changing our industries for the betterment of the consumer. It is the responsibility of companies to ease the transition of its employees during this revolution through the implementation of training programs. The added skills will allow for every employee to remain valuable during this exciting time of change.

References

AiThority., (2019, September 19). The Future of Artificial Intelligence Is Job Augmentation,
Not Elimination. Retrieved December 1, 2019, from
https://www.aithority.com/guest-authors/the-future-of-artificial-intelligence-is-job-augm
entation-not-elimination

Bahrin, M. A. K., Othman, M. F., Azli, N. H. N., & Talib, M. F. (2016). Industry 4.0: A Review
On Industrial Automation And Robotic. Jurnal Teknologi, 78(6-13). doi:
10.11113/jt.v78.9285

Bicchi, A., & Tamburrini, G. (2015). Social robotics and societies of robots. The Information
Society, 31(3), 237-243. doi:10.1080/01972243.2015.1020196

Bugmann, G., Siegel, M., & Burcin, R. (Sep 2011). A role for robotics in sustainable
development? Paper presented at the 1-4. doi:10.1109/AFRCON.2011.6072154
Retrieved from https://ieeexplore.ieee.org/document/6072154

Centre for the New Economy and Society. (2018). The future of jobs report. Retrieved from
http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf

Cerasis_IT. (2014, October 22). Industrial Automation: Brief History and Use in Manufacturing.
Retrieved from https://cerasis.com/industrial-automation

Chuang, A., (2019, August 7) Understanding AI through Holly, the fast-food bot taking breakfast
orders at Good Times. Retrieved December 1, 2019, from
https://coloradosun.com/2019/08/07/good-times-artificial-intelligence-fast-food-workers

Clemens, M. (2016). The robotics & automation solutions streamlining today's packaging
processes: Latest innovations employ fast changeovers, sustainability, flexibility and
more. Packaging Strategies, 26.

Groover, M. P. (2019, May 8). Manufacturing applications of automation and robotics. Retrieved
from
https://www.britannica.com/technology/automation/Manufacturing-applications-of-auto
mation-and-robotics.

Len, C. (2016). Robots in manufacturing applications. Retrieved from

    https://www.manufacturingtomorrow.com/article/2016/07/robots-in-manufacturing-appl

    ications/8333

Magee, A., (2015, Nov 6). Clever handling: Alyson magee examines how robotics can enable

    meat firms to achieve greater efficiency and sustainability across their businesses. Meat

    Trades Journal, 16.

Feldman, M., (2016, Aug 30). Market for Artificial Intelligence Projected to Hit \$36 Billion by

    2025. (n.d.). Retrieved October 27, 2019, from

    https://www.top500.org/news/market-for-artificial-intelligence-projected-to-hit-36-billio

    n-by-2025.

Nova, A., & Schoen, J. W. (2019, January 27). Automation threatening 25% of jobs in the US,

    especially the 'boring and repetitive' ones: Brookings study. Retrieved December 1,

    2019, from

    https://www.cnbc.com/2019/01/25/these-workers-face-the-highest-risk-of-losing-their-jo

    bs-to-automation.html.

Ogbemhe, J., Mpofu, K., & Tlale, N. S. (2017). Achieving sustainability in manufacturing using

    robotic methodologies. Procedia Manufacturing, 8, 440-446.

    doi:10.1016/j.promfg.2017.02.056

Pan, M., Pan, W., Linner, T., Cheng, H., & Bock, T. (2018). A framework of indicators for

    assessing construction automation and robotics in the sustainability context. Journal of

    Cleaner Production, 182, 82-95. doi:10.1016/j.jclepro.2018.02.053

Phc. (2016, September 7). A Brief History of Automation. Retrieved from

    https://www.phcfirst.com/words-in-motion/2016/9/7/a-brief-history-of-automation.

Robotics Online Marketing Team. (2017). Robotic welding: Improving the performance of your

    automated welding processes. Retrieved from

https://www.robotics.org/blog-article.cfm/Robotic-Welding-Improving-the-Performance-of-Your-Automated-Welding-Processes/61

Robotworx.Deboning poultry with meat processing automation. Retrieved from https://www.robots.com/articles/deboning-poultry-with-meat-processing-automation

Taylor, A., (2018, September 13). People around the world think that robots will soon take most human jobs — and that people will suffer. Retrieved from https://www.washingtonpost.com/world/2018/09/13/people-around-world-think-that-robots-will-soon-take-most-human-jobs-that-people-will-suffer/.

Tractica., (2016). Artificial intelligence revenue to reach $36.8 billion worldwide by 2025. Retrieved from https://www.tractica.com/newsroom/press-releases/artificial-intelligence-revenue-to-reach-36-8-billion-worldwide-by-2025/

Vargas, S. (2018). Robots in the workplace. Retrieved from https://www.safetyandhealthmagazine.com/articles/16789-robots-in-the-workplace