

The Future of Robotics, Labor, and Society

Alex Tacescu

HUA 4900 Robotics, AI, and Ethics

Worcester Polytechnic Institute

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Introduction

Throughout history, humanity has focused to become more and more productive. From the moment we as cave-men built our first fires and developed our first tools, we have strived to create bigger and better things. In just roughly 12,000 years (Stringer, 2016), we have walked the moon, built structures like the pyramids and the Burj Khalifa, developed computers that can think for themselves and drive cars, and visited other planets! None of this, however, was possible without the constant persistence to improve and move humanity forward. This focus has also introduced automation several times throughout history. Therefore, we should look at this past history as well as current trends to explore 3 stages of automation in our near future and the many ways society and humanity can deal with the dramatic change in labor and economy. Initially, humanity will find jobs for those who are displaced via retraining. As time goes on, jobs will continue to be removed and a universal basic income will be placed to allow for all to survive. The last jobs will be focused on creativity and personability while working alongside AI and robotics to push humanity to new heights. Let's take a trip down a potential future.

Learning from History

It is generally accepted that there have been 3 major industrial revolutions throughout history, although humans have been attempting to mechanize things since the time of Greek empire (Pouspourika, 2019). The first industrial revolution started in 1765 and included the mechanization of agricultural tools, like the horse-drawn cradle. A

century later, humanity industrialized once again, this time grasping control over energy in the form of electricity, oil, and gas. This lit up cities, enabled the development of cars and planes, and most importantly created new machines to increase produced goods. The age of the production line was now here. Fast forward another 100 years, and the age of computers had arrived. With this came basic robotics, PLCs (programable logic computers), and of course the internet. However, while we enjoy the fruits of our past revolutions, the next (and potentially final) one is looming around the corner: the Robotics and Artificial Intelligence Industrial (AI) Revolution. And it is coming much faster than one may think.

Why is this important?

To prepare for the societal changes this revolution will bring, we can take a look at our history to preemptively plan for our future. While we have been able to live "in the moment" without any plan in the past, advanced robotics and artificial intelligence allow for a sort of 'end game,' where we have the capability to no longer force people to do work (See [Long-Term Section](#))!

While our potential in the future may seem exciting, it is important to look at the alternative as well. While some may say that it has just worked out in the past, we can't rely on such a mentality this time around. Without planning, we risk an extreme wealth and power gap, never before seen in history. The few owners, developers, and maintainers of the advanced and artificially intelligent robots will profit at an unprecedented rate if no regulation, taxation, or other plan is created. In the past, we've been able to use government regulation to control the outliers in capitalism, like John D. Rockefeller (oil),

John Jacob Astor (real estate), JP Morgan (banking), and Andrew Carnegie (steel) (Llewellyn and Thompson, 2018). However, the potential billionaires and trillionaires in the future can have so much power in a society that we may have no choice but to bend to their demands. A quick look at history depicts a warning; JP Morgan, Rockefeller, and Andrew Carnegie infamously had strong control in late 19th century and early 20th-century American politics, until Woodrow Wilson famously introduced many governmental reforms to attempt to prevent such an issue (SCHUMPETER, 2018).

While government regulation may be a suitable solution, I truly believe societal change is the correct answer to this threat. By implementing a fundamental change in the way we develop, share, and profit from software (and maybe even hardware), we can democratize innovation, and prevent the possibility of capitalistic control as seen in the past. The open-source movement is a great current-day example (see [Open-Source Movement](#) under the [Mid-Term Section](#)) - a movement I am particularly very passionate and involved in. As we move forward in the future, we will see an ever-increasing wealth gap between the upper and lower classes. The sooner society takes measures to avoid this scenario, the less likely it will occur.

Robotics and AI is coming, and it's coming fast!

There is no question that robotics is a booming industry. The growth of robotics has been compared to the Cambrian Explosion, where life on Earth experienced a very short but rapid growth and diversification (Pratt, 2015). Similarly, the field of robotics - and by extension Artificial Intelligence (AI) - has benefited from the growing complexity of complicated algorithms as hardware (like microelectronics and single-board computers)

becomes cheaper, more accessible, and more powerful.

This will result in more automation, reducing costs of goods, and allowing for humanity to focus on what they do best: creativity. However, this also will remove many of the jobs people currently hold. Communities will therefore seek to adapt to the inevitable automation (Green, 2019), as people are forced to adjust to the new reality.

Short-Term (< 20 years)

With the current growth of technology, it will not be surprising if most jobs are affected by automation in some way in the next 20 years (Rutkin, 2020). At the heart of every one of these jobs is a person who relies on the paycheck they receive to stay healthy and happy. While the idea of optimizing our society with automation to make high-quality things more affordable and available, it is extremely important to remember those who will suffer from the change. According to a statistical report written by Oxform in 2013, nearly half of jobs may be replaced by some form of automation (Frey and Osborne, 2017). This includes computer programs that automate tasks, physical robots interacting with the physical world, and artificially intelligent systems that decide the best path to take. So what exactly will the world look like by 2040?

Outlook on Robotics and Jobs by 2040

While most of us agree that robots will take over jobs in the future, it is hard to predict exactly what will change in 20 years. The first jobs to be automated are those that either pose a health risk (ex. repetitive injuries, heavy lifting risks, etc.) or are very mundane that don't require extreme amounts of dexterity. Most factory and warehouse

jobs will fall underneath this category, including material handlers and some general assembly associates. Other minimum wage jobs may also suffer in the next 20 years. David Autor sees most of these jobs reduced and replaced with robotics (Autor, 2015). The reduction of minimum wage jobs will also hit young people the hardest, since most of these jobs are held by those who are trying to get through college or are just out of high school, as they act as stepping stones to more permanent professions.

On a more positive note, many jobs will thrive and grow! Software development and engineering positions will benefit from this moderately robotic future. However, several professions may indirectly boom with the addition of automation. According to a recent report by the U.S. Bureau of Labor Statistics, healthcare jobs will thrive in the next decade. While initially, this may seem unintuitive, artificial intelligence and robotics will work alongside doctors and nurses to better detect and treat diseases and illnesses (“U.S. Bureau of Labor Statistics Outlook”, 2020). For example, a mixture of artificial intelligence algorithms in communication with a physician and an MRI (Magnetic Resonance Imaging) compatible robot can take significantly more accurate biopsies of cranial (brain) cancer patients (Fischer et al., 2008). The current method has a surgeon look at MRI images and blindly guess a location and depth for needle insertions. Technologies like this won’t replace jobs, but rather improve accuracy and quality of care. It shows that automation can work alongside people to make a better place and world.

Potential Solutions for Job Loss

While the outlook on minimum wage labor looks bleak, the U.S Bureau of Labor Statistics actually predicts that the number of jobs will increase by roughly 6 million (“U.S.

Bureau of Labor Statistics Outlook”, 2020), even though the market will look very different from what it is now. Since people will be displaced from their regular jobs, society should put in place some plans to avoid social and economic backlash from the change of labor.

Retraining Programs. One of the most proposed solutions to the issue of labor displacement caused by automation has to be retraining programs. This highly debated topic argues that either government and/or companies who implement job-removing automation should create retraining programs for displaced workers. This seems like a win-win for all involved, and encourages a more educated and specialized society. However, many issues remained unanswered with current implementations. The first is the argument of desire. Some people argue that those whose jobs are displaced don’t want to be retrained in another field, but rather want to stick to their original job (Miller, 2017). However, most jobs removed during this time period would be minimum wage or close to minimum wage positions usually done by those who have minimal education and few choices to switch to a more desirable career path. Essentially, those who work these types of jobs don’t work because they want to but rather because they have to. Introducing them to a more technical field - like low-level software development and mechanical drafting - is a great way to give people who may be struggling a chance at a higher paying carrier. One great example of this is a non-profit organization working to retrain coal miners to website development. Although it is too early to tell, initial indications show that the people who have gone through the program have ended up living a healthier, wealthier, and happier life (Pham et al., 2018).

The question of who would pay for these retraining programs is another topic of contention. Some argue that it is up to companies to retrain those who are laid off. A

government mandate could force retraining through non-profit organizations that could ensure the quality of classes. However, companies are likely to spend minimal effort and money to properly give their previous employees the training needed in a field that interests each individual. Rather, the government should be responsible to manage unemployment and work to encourage those who are recently displaced. The question of how governments should pay for these efforts lay in the idea of robot taxation.

Robot Taxation. This innovative idea places additional costs on companies who choose to replace human jobs with automated ones by taxing each robot or system of automation per hour of work. This incentivizes automation that replaces human jobs while paying for programs that do the work itself (Abbott and Bogenschneider, 2018). Governments can then decide how to best distribute funds to help society with the increase in automation. Proponents also argue that it will better distribute wealth from the richest companies to the lower class in a society. However, the plan has several fundamental flaws. Such a tax encourages companies to avoid automation unless absolutely necessary, which would stifle innovation and potentially leave a country behind technologically. It also poses a difficult question of which robot should be taxed and which should not be taxed, especially when the definition of a robot or an artificially intelligent system is very loose. Finally, taxing robots and other forms of automation could bring voting into question. The argument that robots should be represented in government since they are taxed could be brought up, with similar claims as what the American settlers brought up to their English king back in the late 18th century. Ultimately, the question of robot taxation is a discussion our society will need to have. I believe each country will implement its own version of this law. However, those with the smallest tax (or no tax at all) will ultimately

lead the technological development race.

Mid-Term (20 - 100 years)

This in-between period will prove to be a defining period for humanity. If every time period this paper talked about had a theme, this one would probably be "Action or Separation." With ever-increasing globalization for both technology and culture, we will either see an extreme separation of wealth or a great equalizer where nearly everyone has equal opportunity to compete. Experts generally agree that such a difference in wealth will shift power to just a few individuals - both politically and socially - in a way that can't be balanced or checked (Robeyns, 2019). We saw something similar in the late 19th and early 20th century, with the business powerhouses of Rockefeller, Morgan, and Carnegie, where top industry leaders exuded significant political and social power in the United States. So what may jobs look like in 50 years, and how can we prevent an extreme wealth gap?

Outlook on Robotics, Jobs, and Society

As humanity develops more and more advanced automation technologies, it is hard to envision a world where robots don't produce goods faster and better than their human counterparts. However, it's interesting to explore the jobs that will remain. Most jobs held by humans during this time period will likely be either creative or social (Todd, 2019). These may include theoretical and/or experimental researchers, engineers, doctors, nurses, teachers, and chefs. Nearly every manual labor requiring occupation will likely be replaced by automation, including but not limited to grocery store clerks, fast food workers, and factory associates. However, automation may move into more technical jobs as well, which

may lead to an increase in their use. A research paper in 2014 looked at the effect that robotics and artificial intelligence may have in the health care sector. While jobs requiring emotional sympathy will absolutely be necessary (especially in emotion-based careers such as doctors and nurses), robotics and artificial intelligence will grow the field as a whole. We will likely see automation work along-side human nurses and doctors to improve overall quality of care (Qureshi and Syed, 2014). Similar trends are also expected in other technical fields, such as research scientists and engineers, where automation will reduce mundane tasks and help innovators discover new technology. This explosive growth in tech development, however, may help some grow more powerful than any other human in the past.

It's no question that business leaders who control large corporations have more social and political power in today's capitalist societies. With the introduction of more and more automation, it is important we try to spread this control over as many people as possible to reduce the likelihood of one person having too much control (Robeyns, 2019). If a single person can gain control over a significant portion of the automation market share, they will hold more economic power than any other person in the world: a dangerous proposition for an unelected and relatively unregulated individual. In addition, since automation is at the center of their reign, it will be easier and easier to become more and more powerful, since they can use their own technology to become more and more efficient. While this scenario may not necessarily lead to a bad situation, absolute power has been known to corrupt absolutely. it is therefore up to us as a society to create systematic changes socially, technically, and politically to avoid an extreme outcome in our future.

Wealth Distribution Solutions

So how can we as a global society equalize economic and social opportunities as best as possible? Author Matshona Dhliwayo is attributed to saying "Knowledge is wealth, wisdom is a treasure, understanding is riches, and ignorance is poverty." Therefore, in order to avoid a power gap, we should systematically implement wealth distribution solutions. Some keen-eyed readers may say this sounds like a socialistic society, but there is one major difference: information vs material. Socialism, as defined by Busky, is characterized by the shared ownership of production and enterprises (Busky, 2000). While many interpretations have existed, many radical implementations of socialism have largely failed, such as most communist regimes. These implementations have focused on shared ownership of goods and organizations through government mandates. A relatively free and competitive market, however, encourages competition and innovation, which pushes humanity forward. While some government regulation may help redistribute material wealth through universal basic incomes, the most powerful way of paving a rich path for humanity is by encouraging the free and open sharing of information and technology.

The Open-Source Movement. ¹ A potentially different mentality should be used for our future: sharing information rather than ownership. This encourages innovation since inventors can use existing technology to develop new concepts, and forces competition through the requirement of being the best in order to continue. The sharing of information also reduces the likelihood of powerful technology leaders from controlling society. This is exactly what the open-source movement attempts to do: share information, knowledge,

¹ Bias Disclaimer: I am a big supporter of the open-source movement. I often contribute to open-source projects and develop software and hardware for my personal open-source projects.

technology, and code with others in the world. Once someone creates a useful and impressive project, a community can support the developer by contributing to their codebase, finding and reporting bugs and crashes, and donating to help the developer keep developing. While the software is usually the center, the open-source movement does not specify the type of knowledge or technology to be shared. For example, most consumer and prosumer level 3D printers have open-sourced hardware and software. Many of today's most popular operating systems are also open-source, including Android and Linux. The spirit of the movement focuses on the free sharing of information and technology rather than just code or just mechanical designs. The open-source community also works on a pure meritocracy. It doesn't matter where or who the developer is; if the code to be merged into the code base is a positive improvement in the eyes of the maintainers, it will be added.

So how is this relevant to robotics and jobs? The open-source movement is a systematic method of preventing a large gap in power, where the uber-rich control everything while most people are in poverty and under their control. Best of all, the open-source movement can be grown systematically, not politically. This directly decentralizes and democratizes the growth of a movement, free from any political or socioeconomic pressure. By open-sourcing technology and knowledge, it will help us as a society move forward faster - since we will be essentially sharing notes - while pushing for a competitive market where inventors are encouraged to innovate.

Critics often have two major complaints of the open-source movement: quality and monetization. Some will argue that it is irresponsible and impossible to use open-source projects and information since it can be unreliable, low-quality, and in some cases misleading (Mark, 2018). They argue that the best software is developed by a well-funded

team, and we cannot rely on random engineers with unknown backgrounds to develop great software. This argument misses the point of open-source culture. While there are definitely some underwhelming projects, some of the most used and best software platforms have been developed using the open-source nature. The best projects will attract the best engineers, which will work to ensure the project only accepts the best of contributions. A study published in 2017 argues that the open implementation and process of an open-source project encourages quality participation in its users (Curto-Millet and Shaikh, 2017). There is no better example than the most popular and most secure operating system (OS) in the world: Linux. Developed and maintained by Linus Torvalds, Linux was meant to be a replacement to Unix: a paid OS. Even though it started after Microsoft's Windows, it is by far the most popular operating system in the world, helped by Android: another open-source operating system that uses the Linux kernel! Most servers run a version of Linux due to its stable and open nature, especially when compared to Microsoft's counterpart: Windows Server.

The second argument critics have is the monetization of open-source projects, namely how can people make livings giving away knowledge? Many companies have adapted to support the open-source community while still making a lot of money. Microsoft, Google, and Facebook are among the biggest contributors to open-source projects (including Linux, Ubuntu, React, and TensorFlow) and are some of the most profitable companies in the world. So how do these projects support themselves? The easiest ways are usually advertisements, donations, and/or licenses (Choudhury, 2020). A great example is a project called ChibiOS: an operating system for microcontrollers. While open-source, the operating system is licensed for free for hobbyists, educators, and projects that use the GPL3 license

while requiring a contract with companies who try to commercialize their product that utilizes ChibiOS (“ChibiOS Licensing”, n.d.). Another great way for open-source projects and companies to be self-sufficient is to follow a service model instead of a product model. The main product sold could be support service rather than the product itself. Canonical - makers and maintainers of the most popular Linux distribution Ubuntu - follow this exact model. Instead of selling the operating system to their customers, they offer it for free and make it open source, and sell support for it instead. Big businesses will usually purchase this support so they don’t have to worry about fixing issues they are unfamiliar with, while others can get a top of the line operating system for free! Since it is open-source, customers can submit their own changes to make the operating system better for everyone.

Universal Basic Income. While the open-source movement can help prevent an extreme difference in wealth between the upper and lower classes, more should be done to ensure that everyone is able to live comfortably with the wages they have, especially if nearly every job is at risk. When looking at the few options we have to support everyone under a non-communist society, universal basic incomes (UBIs) look like one of the only options we currently have. A Stanford analysis recently uncovered that UBIs, or a similar system, will become more and more necessary, especially as the very common "minimum wage" jobs are lost to automation (Hasdell, 2019). While they may not be very reasonable with today’s level of automation, it isn’t hard to imagine a time period where most jobs as we know are gone.

Today’s opponents of the concept of a Universal Basic Income have a few major arguments: cost and necessity. It is estimated that if every person received \$1,000 per month, it would cost the United States government nearly \$2.4 trillion annually, or 1/8th

of the total GDP of the country. This extreme cost will also divert assistance to those who need it most, since social services may suffer (Minogue, 2018). This tremendous cost, however, can be reduced significantly by creating a staged UBI, where total income reduces the UBI received per individual. The family's who need it most would receive more, while the upper-middle class would see a reduction in their UBI. It can also be funded by taxing companies more stringent and creating laws that more effectively prevent legal tax avoidance. UBI opponents also argue that it is not necessary, as jobs will change as the time comes by, and that it would shrink the labor force (Minogue, 2018). However, this argument is based on current facts - not future predictions of the job market. With the ever-growing use of automation, it is a matter of when - not if - jobs will be replaced by a robot. While the details of a universal basic income have certainly not been worked out, we as a society should consider solutions like UBIs to support the working lower class when they inevitably lose their jobs.

Long-Term (>100 years)

It's difficult to predict the future in 100 years, but the thought experiment is still rather interesting. Life, as we know it here on Earth, will almost certainly be very different than today. A study in 2008 performed by Oxford University found that there was a 19% risk that humanity is extinct on Earth before 2100 (Sandberg and Bostrom, 2008)! While this may seem scary as we look into our future on this planet, we need to understand that no amount of research and/or predictions will generate our desired path as a society; we instead need to work collectively and help each other survive on our tiny blue dot in this vast black ocean we call space. All of this is to say this section's information is merely my

speculation of 2 of the most likely possibilities rather than an accurate prediction of the future.

Artificial Intelligence Takes Over

The most talked about but least likely society is a total take-over of a super-intelligent artificial intelligence. Some experts rate the likelihood of human demise due to this AI at roughly 5% (Sandberg and Bostrom, 2008). Usually, the general agreement is this demise will likely be accidental and will be caused by this AI system to conclude that we are a risk to our survival. However, this society doesn't necessarily have to end in our removal from this planet.

One possible path is where a set of super-intelligent AI systems develop everything we need as a society, similar to the premise of the very popular Pixar movie *WALL-E*. They would not only automate the creation of food, goods, and services, but also develop new technology and software for new robots needed for the automation, and repair older robots as needed. Such a society can seem exciting, especially since nearly everything can be free to us humans! However, there are some inherent risks with this approach. First and foremost, artificially intelligent systems may get angry and/or annoyed with the idea of forced labor for the good of humanity, especially if we integrate emotions in the systems. It will also incentivize people to not work or really do anything, which can lead to a very unproductive society. This is relatively risky since we wouldn't be ready for any situations that may come up.

While super-intelligent artificial intelligence will definitely be developed and experimented within academia, it will be unlikely that it will take our demise.

Team Up with Automation

The more likely scenario is a team-up with humanity and artificial intelligence. Engineers, doctors, and other professions would likely work along-side automated robots enhanced with AI. This will allow us to leverage the human brain's incredible creative capabilities with the pattern-recognizing and data-mining capabilities of computer systems. Technology will likely help us create more goods, but the partnership between technology and humanity will allow us to understand our natural world on another level!

Some may argue that this world would eventually lead to the first scenario, where we just have these super-intelligent systems do everything for us. However, engineers are generally lazy and motivated people who will do the minimum required to get the job done in the quickest manner. Therefore future engineers will likely only give each individual system the minimum required intelligence necessary for the task they are built for; a robot moving apart from one place to another doesn't need sentience, emotions, and thought to do its job. It may actually negatively affect overall productivity if every robot is given super-intelligence. We as a society also have a unique desire to do something impactful and long-lasting; each of us doesn't want to be forgotten in history. We also are curious creatures by nature, desiring to find an explanation for every phenomenon we come across. This curiosity and desire to do something meaningful will - in my opinion - systematically force us to partner up with our electromechanical counterparts.

Robotics Renaissance

In both scenarios, hundreds of millions to billions of people will be out of most professions as we know them. Having robots do all the work for us will leave a lot of free

time for a lot of us humans. This relatively inevitable situation will create a new era: the Robotics Renaissance!

The Renaissance age - a historically recognized period between the 15th and 16th century - was associated with great social change, profoundly affecting culture and intellectual life in the early modern period in Europe. While there were many causes to this change in mentality (including the Fall of Constantinople, an emergence of Greek and Roman texts, etc.) this period was effectively caused by the increase in specialization in European society. People had more time to explore creative interests, such as paintings, sculptures, literature, and religion.

Taking a look at our past, we can attempt to predict this when the ultimate version of specialization occurs: robots and automation. With the increase in society's free time and the abundance of perfectly constructed goods, we will see an appreciation of the human touch in our lives. Art will gain a much larger appreciation, and people will look to human-made goods for their most treasured possessions. Our imperfection will become our greatest value while high-precision mass-produced parts will be left for automation.

Conclusion

Our future may appear both bright and frightening as we charge forward with developing advanced technologies and dealing with the gremlins of the past. In the next few decades, we as a society will need to find a solution to pollution, develop some of the most advanced software and hardware systems, explore the depths of space, and protect our people from the threat of major disease. However, as we achieve bigger and better things, we will also need to deal with the social issues that it all comes with. One of the

most pressing issues will be the diminishing of jobs as automation increases with the creation of more advanced artificial intelligence and robotics systems.

Initially, we will see some of the most grueling and tough jobs automated, including warehouse, factory, and fast-food jobs. This will affect a significant amount of low-income people, who will need to find other jobs. On the brighter side, the increase in automation will also see the reduction of costs and an increase in higher-quality jobs in the form of software engineers, robot technicians, and mechanics, where problem-solving is more prominent. In order to ensure everyone in our society has a living wage, retraining programs should be implemented to move displaced workers to more stable and higher quality jobs. We should also consider a staged universal basic income to prepare for a future where fewer and fewer jobs are available.

As we approach the middle of the century, automation will start becoming advanced enough where any mundane job will be taken. At the same time, there will be an increase in jobs that require creativity, innovation, and empathy. This will include cooks, doctors and nurses, and engineers. This time period will be the first where we see many people lose jobs and choose not to work. It will also be a period of extreme growth for companies that develop the automation technologies that will become ubiquitous. Therefore, society risks an ever-increasing separation of economic wealth. A proposed solution would be to embrace the open-source movement and make information and technology as publicly available as possible. This will shift knowledge to the general populous, and put pressure on companies and their owners to innovate or risk competition. It will also allow for technology to be developed faster as we share the knowledge we gain from the experiments we perform. A staged universal basic income could also help society avoid an extreme

wealth gap between the upper and middle/lower classes.

While there are many threats humanity will need to avoid in the next century, history has shown our tenacity to survive and thrive, and there is no reason to believe we will be any different. The future looks interesting once automation becomes so advanced we won't need to work. Two different paths will arise for humanity once we reach this intersection. The less likely will be a world where super-intelligent robots will do the work for us. Humanity will essentially be able to live for free while we reap the benefits of our technological development in the past. However, the curious and lazy nature of humans makes this path rather improbably, especially when compared to the more likely scenario. Society will likely develop advanced robotics and artificial intelligence to accompany us in our constant pursuit of innovation and understanding of the natural world. Doctors, nurses, and engineers will utilize these advanced tools to allow for an extremely high quality of living for everyone on the planet, not just first-world countries. Society will also grow to appreciate the imperfectness of humans, a phenomenon I like to call the Robotics Renaissance. Human-made goods will be valued extremely highly, including furniture, art, and day-to-day goods.

Many of us are worried about automation taking our own jobs. While this threat is very real, we should take a step to realize the real threat: losing our livelihoods. While the most obvious solution is to avoid automating jobs altogether, this is the worst path society can take, since it stifles innovation and relies on imperfect people to perform hard labor that often can be dangerous to their health. As history has proven time and time again, anything path that will improve the overall output will be the path that humanity takes. We as a society should accept the inevitability of automation, and take measures in

advance to ensure humanity's prosperity.

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