How may robots affect the labour market in the near future?

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Book Chapter

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How may robots affect the labour market in the near future?[1]

Introduction

This chapter discusses how different applications for robots will affect the labour market in the near future. *Near future* refers to the next 10-50 years. It is likely that several occupations will disappear, but new ones will also emerge. However, we claim that the net result will be negative, which means that we will have higher unemployment. These effects will not happen overnight, and not all occupations will be affected. But, this will happen for a sufficient amount of the population for it to become a problem for society.

The observations made in this chapter are not from the point of view of a social scientist, but that of a roboticist. The observations are taken together with readings of scientific literature on automation. I do not claim to have answers to the economic and social scientific problems thrown up, but to raise a set of critical questions for the reader.

All the examples in this chapter are real technologies that exist, not just in science-fiction or future technology. However, most of the examples are still in their research stage and are either not available for the general public, or still very expensive.

1. Thanks to Jennifer Krieger, Karl Wennberg and the reviewers for comments and suggestions on the text.

No one can predict the *future in detail*, *but* this chapter tries to provide a scenario of the future of different kinds of occupations through the perspective of the field of robotics. I have been developing robots for 15 years and will use some examples that I have constructed, but also examples from other roboticists. The chapter does not discuss the risks of automation for all occupations, but instead focuses on blue-collar workers, such as machine operators, the transportation sector with the advent of driverless cars, white-collar workers in offices, skilled professions in the legal and medical spheres, and creative workers.

This chapter raises the following questions:

- Will we have a job to go to in the near future?
- How can we earn our living when more and more jobs will be done by robots?
- How will our economic system handle the increased unemployment?

The objective of this chapter is to raise awareness of potential risks with robotisation, and to spur thinking about how society may change in the near future.

What is a robot?

The *Oxford English Dictionary* define *Robot* as:

"A machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer."

Robots can be categorised in two ways: physical robots, such as industrial robots, and immaterial robots (software or algorithms), such as stock exchange robots. Each copy of a physical robot must be manufactured, while software robots are just source code that is easy to copy. Software robots are cheaper to reproduce and duplicate than physical robots. However, this doesn't reflect the development costs

of a robot. Both physical and immaterial robots need maintenance. Also, physical robots are not just a mechanical structure, but a combination of hardware and software working together.Another classification for robots is based on their level of autonomy, i.e. how much the robot can do by itself. An industrial robot has a low level of autonomy, since it is just following predefined movement instructions and is not aware of its environment. Conversely, a driverless car is much more aware of its environment and therefore has high autonomy. A robotic lawn mower is somewhere in between, because it has a very basic awareness of its surroundings.

The word *robot* was first used by Karel Đapek 1921 in a play called *Rossumovi Univerzální Roboti,* meaning *Rossum's Universal Robots.* Karel described artificial life that was constructed by humans as workers for humanity. The word derives from the Old Church Slavic *rabota* meaning *servitude.*

Background

When *Homo sapiens* first appeared in the African savannah, almost all our time was spent as hunter-gatherers: hunting, collecting roots and fruits, and fishing. But humans are lazy by nature[2]. We do not want to spend all our time gathering food. Instead we created solutions to help us, for example archery and domesticated animals. This has continued through history, evolving into ever-more complicated solutions.

Humans have created machines since ancient times. Ancient Egyptians used complicated irrigation systems and mechanical solutions to build the pyramids. The Greek mathematician Heron wrote and experimented with hydraulics, mechanics, fire engines and even programmable carts.

2. Mar-Nicolle, 'Wired for Laziness'; Hreha, 'Is Human Laziness Human Nature?'.

The industrial revolution 2.0?

At the end of 1700s, 90% of the population in the US was working as farmers[3]. This fell to below 1.7% in 2011.[4] Over the same period the US population has increased from 3.9 million to over 300 million.[5] The industrial revolution enabled humans to replace our efforts with a mechanical counterpart. Not because our muscles were weaker or no longer functioning, but because mechanical muscle were far more powerful and durable. Humans did not change, instead the mechanical solutions we invented surpassed us.

The industrial revolution changed the foundations of the labour market. Farming jobs disappeared when tractors and threshing machines were introduced. At the same time, new occupations were formed in the new industrial sector, such as welders and assembly-line workers.

Society changed and people changed with it. More people moved from the countryside into cities to work in the new industries. New cities emerged around these new industries. The efficiency of production was increased when companies and people became more specialised, though this often requires more educated workers. This led to public schooling and countries introduced compulsory education. With education, people became more aware of their rights, and argued for having rights. Labour unions were formed. Working conditions have improved over the last 100 years, with the standard of living today considerably higher than before the industrial revolution. We have better working conditions, higher salaries and thanks to new technology, better infrastructure and cities.

Now we are facing a new revolution, the digital revolution. This may be considered as a continuation of the industrial revolution, or as a new revolution that will affect society in a similar way. There are both similarities and differences to the industrial revolution. Occupations will disappear, just as some did during the 17th and 18th century. Society became more connected with roads and cars, and will continue to become

3. Diamandis and Kotler, *Abundance: The Future Is Better than You Think*.

4. Ibid.

5. 'Demographic History of the United States.'

even more connected. For example, the internet enables us to participate in meetings without being there physically. This enables people to move back to the countryside thanks to this new infrastructure[6].

However, one big difference is that the digital revolution we are facing now is not just going to replace our muscles, but also part of our mind with a digital counterpart. We are already creating robots and programs with the ability to make decisions. For example, there are stock exchange robots that can act and make independent decisions.

This makes the impact on the society even bigger. What do humans have left when machines and robots both have muscles and decision-making capabilities? How can we compete on the labour market? Not all occupations will disappear, and neither will no new occupations be created. One recent example is the app developer occupation. 10 years ago they did not exit. In 2008 Apple launched the App Store and the mobile app industry exploded, generating $41.1 billion of revenues in 2015[7]. So clearly new professions have emerged, and new technology has given us better ways to communicate and enhance our quality of life.

But the difference is that technology will continue to get better and better, while humans have barely changed since we migrated from the African savannah. Our biological evolution has no capacity to match the rate of development of computers and algorithms.

While the changes to our different occupations will not happen overnight, it has already started and will continue affecting society in the coming century. We must be prepared for this change and try to adapt ourselves and society to higher rates of unemployment.

Do new technologies lead to new jobs?

Horses have had different uses throughout history. They started out with labour-intensive tasks in mines, but were replaced with more-efficient and cheaper machinery. Humans found other tasks for horses, like carrying letters between cities. Horses live a better life now. Seen in this way, it is logical to think that new technology always leads to higher

6. Dominiczak, 'Countryside Population to Increase Dramatically by 2025.'

7. McGoogan, 'App Revenue Will Overtake the Music Industry This Year.'

standard of living.

There is no law of nature that states that new technology will create new and better professions. New technology leads to a higher standard of living and economic growth, but not necessarily to new professions. *Post hoc ergo propter hoc*, there is no causality between new and better technology and more jobs.

In fact when the new mechanical horses (i.e. cars) were invented at the end of 19th century, horses had a harder time finding a use. Horses were no longer profitable to the labour market and no longer paid for themselves. Cars were better suited for the new cities and infrastructure that emerged during the 20th century. The only occupation that horses are still today used is in the police and for forest conservation.

With our political leaders stating the need for investment in new technology, such as automation and robotisation, on the basis that it will create new job opportunities, in fact the opposite is true, the very outcome of automation is to reduce the demand for human jobs.

The argument that labour unions will ensure job opportunities stay in their home country, and prevent people from losing their jobs, has been proved by history not to endure in the long run, even if this may be true at the start. Labour unions and worker movements have always tried to prevent factory owners laying off personnel, but the economic incentives are so powerful and so strong that labour unions and worker movements eventually have been forced to succumb. For haulage contractor companies, personnel costs are the second-largest expense (the largest being diesel). Companies may try to reduce this expense to increase profit.

When James Hargreaves invented the Spinning Jenny in the 18thcentury, criticism was severe because many spinners were laid off and lost their only income. Textile workers formed groups, the Luddites, to sabotage the new machinery. The word *sabotage* originates from the French word for *clog* (*sabot*), when workers placed their shoes in the weaving looms. Also, the phrase *to put a spoke in someone's wheel* originates from the time of the industrial revolution. Labour unions have always tried to stop technology that threatens jobs. Yet after 5-10 years the Luddites disappeared (after military intervention), and some dec-

ades later workers eventually accepted the fact of new technology. In fact, the employee conditions have improved. Today, no one would like to change jobs with the dirty industrial environments of the late 18th century. But, it was hard for workers to give up their jobs to mechanical counterparts. The key point is that these changes were good for the society and future workers, because their conditions improved, but the changes were tough for the individual employees at the time.

In conclusion, new technology doesn't lead to new jobs; actually the goal of new technology is often the opposite, to automate a process. And even though individuals and groups such as labour unions sometimes try to prevent new technologies from replacing the human workforce, history shows they will eventually give up and accept the new conditions.

Blue-collar workers

The general public either associates the word *robot* with sci-fi robots, such as R2-D2, or with Industrial Robots that manufacture cars. Industrial robots are among the earliest robots that replaced the human workforce. The first commercial industrial robot was used in the 1960s and used in the automotive industry for dangerous tasks.

There are several advantages of using robots instead of humans in the manufacturing industries:

- A robot can execute heavy, monotonous and dangerous tasks, improving occupational health and safety (OHS) for humans.
- A robot is able to perform tasks repetitively and very precisely, leading to improved quality and decreased line rejection.
- A robot doesn't require any salary and is more efficient, leading to cheaper production.

All these factors lead to fewer employees in the manufacturing indus-

try. This has been the trend since the 1960s[8]. More products can be manufactured using fewer workers, and those that are working are undertaking supervision and maintenance instead of manufacturing. When my grandparents graduated from secondary school they could get a job at the ironworks or paper mill. Today you need a high level of education to work in the industry. It is no longer possible to just learn on the job as apprentice. We are getting rid of 'easy' tasks (skill level 1 and 2 on the ISCO-08 categorization[9]), and replacing them with robots, keeping the more advanced tasks (skill level 3 and 4[10]) for humans. This is a problem since not everyone has access to, or an interest in, further education.

In terms of development, new industrial robots are emerging, such as the collaborative robot Baxter from Rethink Robotics and YuMi from ABB. We can see an analogy in the history of computers. The industrial robots of the 1960s were much like the computers of the 1940s. The ENIAC computer didn't have a user interface and no digital stored program memory, so cables had to be manually reconfigured. The first industrial robots took several months to reprogram for a new task. In the 1980s this changed, when computer experts started to develop home computers that were easy to use, programs could be switched using floppy disks and high-level programming languages were born, such as BASIC, which were able to reprogram computers (instead of reconnecting cables). Today, people can buy home robots, such as robotic vacuum cleaners and robotic lawnmowers, and the experts are building their own robots, just like they built computers in the 1980s. History repeats itself with an offset of 30 years.

In the 1980s, computer development exploded. We are likely to see the same happen to the robotics industry. When robots get easier to handle and don't require expertise, the general public will start to use them in their everyday life. With demand increasing, the price will decrease. The speed and robustness of the robots will also improve, just like computers have increased in speed. 30 years after Apple introduced the Macintosh computer, everyone has an iPhone or other smartphone

8. Wyatt and Hecker, 'Occupational Changes during the 20th Century.'

9. Hunter, *International Standard Classification of Occupations.*

10. bid.

in their pocket that is several hundred times faster. Computers nowadays are also easier to interact with, using touch interfaces and voice command services like Siri.

The state-of-the-art robots are at the level where computers were in the 1980s. They are starting to get easier to use with lead-through techniques[11] and better programming tools (like ROS[12]), and are also starting to sneak into everyday use, i.e. lawnmowers. Collaborative robots are on the rise, with Rethink Robotics launching the Baxter in 2012[13] and ABB releasing competitor YuMi in 2015[14]. Both these robots are intended to work side-by-side with humans. Baxter has eyes and a face to interact with his human co-worker and YuMi leans forward to indicate submission or subjection. These robots are often used for assembly of consumer electronics previously done by humans.

However, Baxter and YuMi are still very slow, much slower than their human counterparts. But they don't need coffee breaks, sleep or a salary, making them much cheaper operationally.

Today, robots are actually relatively cheap to acquire (or, if you like, to 'employ'[15]). Baxter costs about $40,000[16]. The median salary for an assembler or welder in Sweden is approx. $2,750/month[17], with employment tax at $850[18], resulting in a cost of $43,200 yearly. So, Baxter's return on investment is less than one year compared to a human doing the same work. While there are additional costs for programming Baxter, this is easy to do, and could be done using existing employees that knows the processes and production flow.

In 2014, I competed in an international cooking competition[19], or rather, a robot I developed competed, since I can't cook at all. The competition was held in Madrid and the robot was taught to cook gazpacho.

11. Graf, Lead-through robot programming system.
12. 'Robot Operating System.'
13. 'Baxter (Robot).'
14. 'IRB 14000 YuMi.'
15. FinWire, 'EU-Utredning: Arbetsgivaravgift För Robotar.'
16. 'Build a Baxter Robot | Rethink Robotics.'
17. 'Montör Löner'; 'Svetsare Löner.'
18. 'Beräkna Arbetsgivaravgift.'
19. 'HUMABOT Challenge.'

It did this so well it won the competition! Cooking isn't that hard. A simple robot can follow a recipe and mix different ingredients together in a predefined order.

Most restaurants have a fixed menu every day. It would be easy to replace human chefs with their mechanical counterparts. China has restaurants where the food is prepared by robots and machines[20]. The food will always be of the same quality and the restaurant can be open around the clock. More common is to have robotic waitresses[21]. In 2014, Lidköping in Sweden opened the first restaurant in Europe with robots that can talk and take orders from customers and deliver food to the tables[22]. Without having to pay salaries, the restaurant owner can lower the price of the food. Former McDonald's CEO Ed Rensi has said that robots will take over staff jobs at the fast-food empire, because it's cheaper than employing humans[23].

To summarise, we have seen how assembly-line workers and welders have been replaced by industrial robots ever since the 1960s. But, during the past 10 years, we have seen an increase of collaborative robots that can do more agile tasks and work together with humans. Examples include assembling consumer electronics and cooking food at restaurants, tasks that humans traditionally have done for a living. We have also seen how the development of industrial robots is following the same path as the development of computers, and are getting easier to use and easier to reprogram for new tasks.

Transportation sector and driverless cars

If cars were the *coup de grâce* for the horse, driverless cars will dominate our path for the future. Transportation will be transformed in the coming 10 years[24]. Driverless cars are not just the future, they are the pre-

20. Ward, 'Robot Restaurant: Robots Cook Food and Wait Tables in Harbin'; Hiden, 'Robot Restaurant Where Machines Cook and Serve Food to Customers.'

21. Nguyen, 'Chinese Restaurants Are Replacing Waiters with Robots.'

22. 'Lidköping Öppnar Europas Första Robotkrog.'

23. Haworth, 'Building Robot McDonald's Staff 'Cheaper' than Hiring Workers on Minimum Wage'.

24. Fields, 'Ford's Road to Full Autonomy'; Banker, 'How Will Transportation Change Over The Next 10 Years? '.

sent. Self-driving cars are legal in 10 states in US[25]. Several companies are developing their own driverless cars.

Humans are bad drivers. More than 90% of road accidents are caused by human error[26]. We text while driving, talk while driving, we have a hard time focusing longer than 20 minutes at a time[27]. A computer can be super-focused, hour after hour. In addition, human responsiveness is in the magnitude of 200-300 ms[28], while a computer can react in a few nanoseconds, over a million times faster. Humans don't have time to make a decision before an accident happens. In addition, humans do not act rationally when stressed. During, or just before, an accident, when we should be acting most rationally, the body produces a lot of cortisol and noradrenalin, which prevents us from making well-founded decisions[29].

It is easy to see from tests that algorithms already today makes for better driving than a human driver. The main problem is that humans rarely trust machines to drive. We want a person to drive the airplane or train because it *feels* safe. It's a common feeling that a person makes better decisions, especially if they are in the vehicle and risking their own life[30].

In future, we will likely look back on the 20th century and think we were crazy to let humans drive cars over 100 km/h. Biological creatures are not made for such velocities, our brains do not have that capacity. We don't have the ability to make well-informed decisions during an accident. First, we just don't have time to make a decision (just a few milliseconds is faster than our reaction time[31]). Second, we don't have the information needed, for example, we get a binary signal from an indication lamp when driving on a slippery road, while

25. 'Self-Driving Vehicles Legislation.'

26. Olarte, 'Human Error Accounts for 90% of Road Accidents.'

27. **Dukette & Cornish**, *The Essential Twenty : Twenty Components of an Excellent Health Care Team.*

28. 'What Is the Average Human Reaction Time?'.

29. Kowalski-Trakofler, Vaught & Scharf, 'Judgment and Decision Making under Stress: An Overview for Emergency Managers.'

30. Mehta et al., 'Consumers' Perceptions About Autopilots and Remote-Controlled Commercial Aircraft.'

31. 'What Is the Average Human Reaction Time?'.

an autopilot can have the exact friction coefficient between each wheel and the ground. A computer will have much more information on which to base its decision.

The transportation sector will change dramatically during the next 10 years[32]. Transportation inside factories are already driverless: paper rolls at paper mills are being transported by AGVs (Automated Guided Vehicle) and driverless trucks move iron ore at mines. But these robots (since driverless cars *are* robots) are not generally known about. Another example is the HHLA Container Terminal Altenwerder in Hamburg, where AGVs and cranes work around the clock without human drivers. It is easy to develop self-driving trucks in a controlled environment: there are no pedestrians and computer models can be made of the surroundings, with electromagnetic wires placed on the ground, just like a lawnmower moves around a garden. A company can save money since salaries don't need to be paid for drivers and the trucks and cranes can operate at all hours.

The next step is to allow self-driving cars in cities, a more challenging task, since we can't forbid people from walking around the city. Cities change and self-driving cars must be able to learn and adapt while they are driving. This is far from impossible.[33] Several campuses in the US have launched self-driving shuttle buses in the past year.[34] These have high-definition maps of the surroundings, as well as distance sensors to detect pedestrians.[35] Volvo, among others, is developing wireless road trains, where several trucks drive in convoy, with just the first having a human driver, with the others communicating wirelessly[36]. Uber, Tesla, Google and others are developing self-driving vehicles to replace buses, taxis, trucks and private cars.

The main problem with driverless cars is not of a technological nature, the main problem concerns the legal framework. To prove that it

32. Banker, 'How Will Transportation Change Over The Next 10 Years?'; Fields, 'Ford's Road to Full Autonomy.'

33. 'DARPA Grand Challenge (2007).'

34. Yadron, 'Self-Driving Cars Coming to a College Campus near You as Price of Tech Drops.'

35. Miller, 'Autonomous Cars Will Require a Totally New Kind of Map'; Fields, 'Ford's Road to Full Autonomy.'

36. 'The SARTRE Project.'

isn't that hard to build a driverless car, I built one myself in the spring 2015[37]. While far from the advanced cars Volvo and Google are developing, it proved possible to build a car that functioned in a city. Other private individuals have done the same; George Hotz built a self-driving car that functioned in traffic.[38] The technology is not the limitation here, it is the law that prevents further advances.

The law represents a competitive disadvantage, with companies preferring to develop driverless cars in countries where it is legal. Why would an entrepreneur with a vision to change the transportation sector establish a company in Europe, where all vehicles without a driver are prohibited? There would be a clear advantage to locating headquarters in the US, where it is legal to undertake practical tests. Companies (and future job opportunities) may be hampered by detrimental European laws.

If we look at the labour market in Sweden, over 55.000 people work as truck drivers[39]. The US has 3.5 million active truck drivers[40] and is the most common occupation in many states. There are thus over 3.5 million people that risk losing their job in the next decade. They may find new jobs, but the level of complexity of occupations is increasing and requires more educated employees. Not everyone is interested in further education. How can these people cope with this rapid technological change?

To conclude, there are large companies already developing self-driving cars and trucks, and autonomous vehicles will appear on the roads in the coming 10 years. Accidents will fall, since driverless cars have both more time and more information for decision-making. The downside is that many people may lose their jobs when cars can transport goods by themselves. The question is, how will society cope with even more unemployment?

37. Nohrstedt, 'Självstyrande Bil Byggd På En Vecka.'

38. Zelenko, 'On the Road with George Hotz's $1,000 Self-Driving Car Kit'; Vance, 'Meet the 26-Year-Old Hacker Who Built a Self-Driving Car...in His Garage.'

39. '30 Största Yrkena.'

40. 'Trucking Statistics.'

White-collar workers

White-collar workers (such as administrators and office workers) are more likely to be replaced by immaterial robots than by physical robots. Replacing a white-collar worker does not need mechanical muscle, but instead, software and algorithms. It is obviously cheaper to produce software robots, because this doesn't require actuator and hardware solutions, and once an instance has been developed, it is cheap to reuse the software for more, copying it at almost no cost. In addition, white-collar workers usually have higher salaries than blue-collar workers[41] and therefore a company has a bigger economic motivation to replace them. It may be impossible to replace every task a human worker does completely. Even if only a small fraction of daily work can be automated, the employer will still save money, since it doesn't need to pay a salary for as much time as before.

Automated scripts and tasks have been used for long time, particularly by IT companies. This has been expanding to other companies during the past decade. It can be something as simple as a spam filter in your inbox, so you don't manually have to open every email, to more complicated policies that install computers automatically, in schools and companies, with all the necessary software.

In addition, the development of machine learning during the past 10 years has made it possible to program software that can learn and adapt to new situations[42]. Machine Learning is a research topic within the field of Artificial Intelligence. To create a program that learns by itself neural networks are often used, where the program resembles how the human brain works with synapses and neurons. There are two types of self-learning algorithms: either supervised, where someone needs to tell the algorithm, "This was correct", or unsupervised, where the algorithm itself evaluates if its action was good or bad.

Stock-exchange robots are already taking decisions by themselves. When to buy, when to sell and to whom? No one has taught the robots exactly when and where they should undertake the transactions. They

41. Berg, 'Gap between Blue-Collar and White-Collar Pay Increases.'

42. Kober, Oztop & Peters, 'Reinforcement Learning to Adjust Robot Movements to New Situations.'

analyse the stock market and learn from how the market behaves; they develop and adapt and are improving rapidly. They are an unsupervised artificial intelligence, with the pre-programmed goal to make as big profit as possible. Stock exchanges have been dominated by humans since their inception, but since the beginning of 21st century, computers have started to make automatic trades. This began just as small scripts, becoming more and more advanced. By 2012, algorithms were managing over 85% of total market volume[43], and this percentage is increasing.

No programmer can learn what an entire job entails. It would take forever and when eventually finished, the tasks would have changed. Writing a program that replicates someone's work would take a long time and is not sustainable. But what the programmer can do is to develop a self-learning algorithm that can be installed in a computers and observe what an employee does every day. It can analyse every action and keystroke. With this huge amount of information, the algorithm can figure out how to execute any job. Maybe not everything, but enough to free up an employee's time. Fewer people can do more work when computer algorithms are utilised.

Algorithms were by 1997 already beating humans at chess, when IBM's Deep Blue defeated Garry Kasparov. A more recent example is Google's AlphaGo, that played Go and won against Lee Sedol in March 2016. To play chess, Deep Blue analysed all possible movements and selected the ones with the highest possible chance of winning the game. While this constitutes a huge amount of possibilities, they are not impossible for a computer to calculate. The case of Go is different, here there are way too many possibilities for an exhaustive search, so the robot/algorithm needs some form of what we humans call **intuition** or gut feeling. This feeling has been implemented by observing thousands of matches between skilled humans. The next step was then to compete against instances of itself. The same kind of strategy can be used to learn intuition in negotiations and mediation between parties.

Did you read the news this morning? The chance is that the articles

43. **Glantz & Kissell,** *Multi-Asset Risk Modeling : Techniques for a Global Economy in an Electronic and Algorithmic Trading Era.*

you read were written by a software robot. The Swedish news agency TT is using robots to produce local news[44]. The robot will use statistics and local data to customise articles and notices with a more local touch. The news agency can't write 290 different notices for all municipalities in Sweden and today they can't offer specific notices for a region, municipality or county council. With robots, news agencies can deliver more material to their customers[45]. Also the AP international news agency has been using robots for a long time. Many articles about sport and economics can be written by computers[46]. For example, the software can assess the statistics and history of a team, or a specific player, and write about similarities and differences to previous matches. Today, newspapers can only afford to visit matches in the highest leagues, but demand for news about local teams playing in a lower division can be satisfied by software robots, so that interested readers can access news about their team in the local newspaper or on the internet[47].

Today, the news produced by software robots is supplementary and adds extra value for customers. Yet, computer programs are getting better at producing text, and there have been experiments with robots that write fiction[48].

The owners of news agencies will save money if they can use software instead of journalists to produce good-quality material. What will the impact be on the quality of articles and investigative journalism? Complex article series are hard to produce nowadays, given newspapers are dependent on online advertising, which favours 'clickbait' websites, such as Upworthy and BuzzFeed.

To summarise, robots can already make independent decisions (stock-exchange robots), analyse complex events (the Alpha Go robot) and write texts and reports (news robots). Many jobs in these three domains can all be replaced to a degree sufficient that it will impact the labour market.

44. Äng, 'TT Bygger 'reporter-Robot."

45. 'Mittmedia Börjar Med Robotjournalistik.'

46. Nordström, 'Robotarna Tar Över Journalistiken.'

47. 'Robotar Objektivare Än Journalister.'

48. Gervás, 'Story Generator Algorithms'; Kazemi, 'NaNoGenMo 2015'; Ahlström, "Det Är En Tidsfråga Innan vi Ser Romaner Skrivna Av Datorer."

Highly skilled workers

The examples of truck drivers and machine operators centre around replacing low-skilled jobs. But, the creation of digital minds that can make decisions by themselves mean educated workers may also fear that their jobs will disappear in the future.

If we look at lawyers and law firms, almost all of them have already *hired* robots that do research for them. Automatic computer programs assist them with research and investigation. When one thinks about lawyers, we think they spend most of their time in court giving closing arguments. But, in fact a big portion of their daily work is spent in the office. For example, economic crime lawyers need to read through emails, correspondence and bank transactions looking for deviations. Until the 1980s most of this work was done manually, reading folders of bank transactions and economic reports. It took time, several weeks, to find the one missing receipt or evidence of a bribe. After the arrival of large-scale computers and the internet, all this is done by computers, and the algorithms are getting smarter and smarter every day. Using computers greatly reduced the time needed to find patterns and deviations. Law firms can increase their profits, because they don't need a person working for several weeks when a computer can do the same job in a couple of hours. But saving time or money wouldn't be the main reason to switch to computer algorithms. A human reading through several thousands of letters and bank transactions can lose focus and it is easy to miss a small detail or to make connections between disparate bits of data. A computer is perfect for this, will keep focus and notice small deviations and find patterns[49].

Analysing huge amounts of data is something humans are not designed for. Our brains don't have the capacity to read and process all the data that is needed for the complex events in our world[50]. We haven't changed notably since the days of the African savannah. We have the same brains now as then. But the world nowadays is much more connected and complex. We are getting bombarded by more during one day than

49. Larsson, "Advokatrobotar' gör Det Billigare Och Lättare Att Få Juridisk Hjälp.'

50. Arbesman, 'Is Technology Making the World Indecipherable?'; Badger, 'Transit Systems Are Growing Too Complex for the Human Mind.'

during our whole life in ancient times. We can't process all this information. But computers can. This research field is called 'big data' analytics.

One robot that is particularly good at big data analysis is IBM's Watson. Watson was designed to play the quiz game Jeopardy! and in 2011 beat former winners Brad Rutter and Ken Jennings.[51] Watson was not allowed to connect to the internet and only used its internal information. But storing information is not a big deal for a computer, the impressive thing was the capability to process human language and understand what it means. In Jeopardy!, competitors are given a subtle and hard-to-understand fact, and must supply the question that would produce the same answer. This is a hard task for a computer. A computer needs to analyse the facts, and in many cases, has to have enough associative ability to understand what the question really is. It can be anything from quotes from a movie to abbreviations of chemical elements.

But Watson's abilities extend beyond Jeopardy! to the medical field. Hospitals in New York and Ohio use Watson to recommend treatment for cancer patients. A human doctor gives Watson information about the patients and Watson responds with a few confidence-scored recommendations. In addition to the information provided by the human doctor, Watson can access research material, clinical studies, journal articles and data about different treatments and drugs. Every day new articles are published in a rate that no human can match[52]. Watson can detect similarities between different kinds of courses of a disease and how different drugs relate to each other with adverse effects. Watson can read through 20 million cancer research papers and come up with the proper diagnosis within ten minutes[53]. This is far better than any human doctor. Watson is constantly learning and improving through-getting results from former patients and reading new medical studies. We may still need human doctors, but the need will decrease when more hospitals use a Watson for diagnosis.

Since Watson is an immaterial robot, there is in theory nothing that

51. 'Watson (Computer).'

52. Van Noorden, 'Global Scientific Output Doubles Every Nine Years : News Blog.'

53. Ng, 'IBM's Watson Gives Proper Diagnosis after Doctors Were Stumped.'

prevents IBM from taking the code and making an app of it. However, the computational power of a mobile phone is currently not sufficient. IBM can instead place Watson in the cloud and let all app users connect to it. If everyone has a doctor in their mobile phone, what is the purpose of a human doctor? The robot will most likely give a correct diagnosis more often than a human doctor, because it has more data to on which to base its decision.

Medical applications have extended beyond the diagnostic medical sphere to surgery. One of the earliest robotic surgical systems was the ZEUS system[54] and the competing Da Vinci Surgical System[55]. These systems are not autonomous, instead they assist human surgeons. The robot is remotely operated by the human surgeon, taking their movements and shrinking them to minimal, stable movements. A human has bad eyes and can't see much less than 1mm, and can have tremors in movement. The robot acts as a magnifying glass and guides the human to correct locations. This makes the surgery smoother and less invasive. In addition, human surgeons don't need to be in the same room, or even the same country, as the patient. In 2001, surgeons in New York completed the first tele-surgical operation on a patient in Strasbourg, the Lindbergh operation[56]. In the Third World, with low availability of good surgeons, ZEUS has opened the possibility of improving health in the poorest parts in the world.

Research on cognitive and social robots is advancing. In Sweden, the JustoCat, and Japan, the Paro Therapeutic Robot, are both used for dementia patients.[57] In studies it has been shown that these patients feel better and have lower stress hormone levels if they have an animal to take care of. Unfortunately, this can't be another living being because they may forget to feed or walk it. But a robot doesn't need this. JustoCat is a robot cat and Paro is a robotic seal that reacts and behaves just like a cat, but with mechanical entrails. When people with demen-

54. 'ZEUS Robotic Surgical System.'

55. 'Da Vinci Surgical System.'

56. 'Lindbergh Operation.'

57. Aremyr, 'Kontakten Mellan En Sälrobot (Paro), En Taktil Värmekatt Och Personer Med En Demenssjukdom.'

tia take care of JustoCat or Paro they are happier and less stressed. [58]

To conclude, we have shown that even advanced professions, such as lawyers and doctors, can be replaced by digital counterparts. We are not going to lose all our human doctors during the coming 50 years, but some doctors will lose their jobs to digital solutions but the impact on patients will be positive, since they will get faster and more accurate diagnoses. The same applies to lawyers, the law firms can deliver better and faster results, but individual employees may lose their jobs.

Creative workers

What can humans do better than robots? Many answer that robots can never have feelings and be creative. They may be right, or wrong, depending on how you define creativity and feelings. What if a robot can imitate human feelings and reactions? If a robot reacts in the same way as a human, on the same occasions, does the robot have feelings or is it just imitating those feelings? Where do we draw the line between learned and *real* behaviours?

I have built a robot that painted artwork. A machine that paints the same painting every time is easy to make, but my robot painted different paintings. It won silver at the World Robot Olympiad in South Korea in 2009[59]. Was my robot creative? Some may say yes, others no.

Emily Howell is a robot (a computer program) that composes music and has released two studio albums. The program was developed by David Cope in the 1990s as a project in Artificial Intelligence and music[60]. You just give Emily the genre and duration and it will compose it for you. Because Emily is a software robot, it is capable of composing more pieces in a week than there are seconds during a week. By contrast, a human musician needs breaks to eat and sleep. Emily is easy to

58. Jøranson et al., 'Effects on Symptoms of Agitation and Depression in Persons With Dementia Participating in Robot-Assisted Activity: A Cluster-Randomized Controlled Trial'; Robinson, MacDonald & Broadbent, 'Physiological Effects of a Companion Robot on Blood Pressure of Older People in Residential Care Facility: A Pilot Study.'

59. 'World Robot Olympiad.'

60. Cope, 'Emily Howell.'

duplicate and there can be several Emilys producing music at the same time. Emily learns and is influenced by what it listens to, but never just copies it. This means that every instance will produce slightly different music[61]. Would this mean Emily has creativity?

Humans are not overly special, our creativity is just chemical reactions in our brain. There is nothing that prevents us from simulating chemical reactions in a computer. If we increase the simulation size and speed, we could theoretically simulate the whole brain, and arrive at digital creativity that is identical to how human creativity works. Currently, two research projects attempt to imitate the human brain, the EU's Human Brain Project[62] and the US's BRAIN Initiative[63].

Why would we pay a human to make music that Emily can produce for free? Will it be possible to earn a living doing creative tasks in the future, when robots can do the same tasks?

We can, of course, still devote ourselves to music or art, just not for a living, but rather as a way to express ourselves and because we enjoy it. Like the nobility during the Renaissance and Baroque periods, Mozart and Beethoven did not primarily make music for payment. Leonhard Euler and Sir Isaac Newton didn't discover new maths and physics to earn money, but because they were dedicated to these subjects. The privileged classes and skilled artists paid by patronage had time to devote themselves to maths, music or artwork, in contrast to the lower classes that had to work to feed their families. If robots can undertake work for humans in the near future, more time can be spent on intrinsically motivated work, hobbies and leisure time.

Art and other areas of creativity is the last sector robots will likely conquer. But, even if this is several decades in the future, research is so active that we already have robots that can produce fiction, music and art. In summary, even these occupations are not safe in the future.

61. Adams, 'David Cope: 'You Pushed the Button and out Came Hundreds and Thousands of Sonatas.''

62. 'Human Brain Project.'

63. 'BRAIN Initiative.'

Conclusion

The changes we have described will not happen overnight, and some may never happen. But the robots described already exist, they are not science fiction. Society is constantly evolving, but we often don't notice it. One day everyone had a smartphone and our behaviour had changed, but this didn't happen overnight. It is easy to see changes in the past, but not what is happening right now. One often sees development of society as linear, looking at what happened in the past 30 years and imagining the same amount of development will happen the next 30. But what we can see is that the rate of development is increasing and accelerating. What you have experienced today is probably more than a farmer in the 1800s experienced in one year.

Our generation is not any lazier than ones before. We are just as diligent and have an equally high work ethic. But the technical change has surpassed us. Just as the horse was not replaced by cars because it was lazy, it was replaced because cars are a better means of transportation. The main aim of automation is to replace human workforce with digital and mechanical counterparts, not to create new occupations. The digital revolution will sooner or later remove humans from the labour market and make us all unemployable.

A major problem is that the purchasing power of a community decreases when people become unemployed. There are no easy solutions. Maybe each family will in the future own a robot that is working to make money for its owners. But why would a company hire robots when they can buy them cheaper themselves? Another solution is that of a basic income,[64] a minimum wage to increase individual purchasing power. This may be hard to implement, though several countries are debating it[65] and testing it on a small scale[66].

Rather than being cynical and technophobic, this chapter seeks to emphasise that technological change can be something good: it will lead to better living conditions and open up many possibilities. We will

64. Mellqvist, 'Gratis Pengar När Robotar Gör Jobbet.'

65. Stewart and Elgot, 'Jeremy Corbyn to Investigate Idea of Universal Basic Income.'

66. Diaz, 'Basinkomst Ska Testas I Finland'; Kosk, 'En Väg till Ett Nytt Samhälle.'

have robots that can treat cancer. But, we can't ignore the risks. Similar risks were discussed in the past, by for example, David Ricardo in the 19thcentury, but the difference here is that the robots are also capable of decision-making.

Society can't solve a problem it is not aware of. This chapter intends to raise awareness of the digital revolution we are facing. We can form our future. What kind of society do you want?

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