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The history of the industrial robot

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Abstract

In this report some phenomena and events in the history of industrial robots have been described. The prerequisites are mainly the early automation in the industry, together with the playful automatons. With the computer and later on the integrated circuit, it was possible to develop the first industrial robots.

The first robots were used for simple tasks as pick and place, since they had no external sensing. They replaced humans in monotonous, repetitive, heavy and dangerous tasks. When the robots could manage both a more complex motion, but also had external sensor capacity, more complex applications followed, like welding, grinding, deburring and assembly. The usage of industrial robots can nowadays, roughly speaking, be divided into three different groups; material handling, process operations and assembly.

In general, industrial robots are used to reduce costs, increase productivity, improve product quality and eliminate harmful tasks. These areas represent the main factors resulting in the spread of robotics technology in a wider and wider range of applications in manufacturing industry. However, introducing robots do not solve all problems. Automation, productivity, employment are complex questions and the connections between robots and labour can be discussed much more.

Keywords: Robot, automation, automaton, history

Contents

1 Introduction

The aim of this work is to shed some light on the development of the industrial robot. In the first section, characteristics of industrial robot and robotics are discussed. Then a short summary of automation and the prerequisites for the robotic area is given, because one cannot say something about industrial robots without mentioning the history of automation. Thereafter the historical robot mechanics (automatons) and the early steps of industrial robots are described. Finally, socio-economic factors of robotisation are discussed.

We begin with a short introduction to the central word *robot*, as well as a first insight into the feelings associated with robots. Ever since the beginning of the era of robots, they have interested and maybe also frightened human beings. Are they dangerous? Will they steal the work from us? How can we make use of them? In some sense one can say that it all began when the word *robot* itself was created. The term *robota* exists in several Slavic languages and the original meaning is heavy monotonous work or slave labour (drudgery). The Czech playwright Karel Čapek wrote R.U.R. (Rossum's Universal Robots), which had its premier in Prague in 1921. By that the word robot received another meaning. In the play R.U.R. the worker robots serve the humans by doing their jobs, and the robots therefore have no need of feelings or intellectual life. After a while they revolt and kill their human master Rossum and also destroy all life on Earth. In the play the robots are characterised by both super human strength and intelligence.

It is interesting to note that the story of R.U.R. takes place in the 1960s, which also later turned out to be the decade when the industrial robots were introduced in the industry. People then generally thought of the robot as something negative and destructive. Even Charlie Chaplin had a powerful influence in the debate with his film Modern Times from 1936, where he shows the dark sides of the highly automated world, see Figure 1. It was an effective weapon in the debate concerning automation of American factories. Another example is the film Sleeper from 1973, where Woody Allen disguises himself to a robot-butler in the hostile, futuristic world. [12, 14, 4, 3]

Figure 1: Charlie Chaplin among the gearwheels in the film Modern Times, 1936 (left). Woody Allen, disguised as a robot-butler, to be able to avoid pursers in the hostile, futuristic world, in the film Sleeper, 1973 (right). [10]

2 How is an industrial robot characterised?

Before we enter the history of the industrial robot, a definition of the terms industrial robot and robotics are actually needed. In this section some fundamental laws and definitions for robots are mentioned.

2.1 Fundamental laws of robotics

One cannot write an introduction to robotics without mentioning the fundamental laws of robots. The well-known Russian writer of science fiction Isaac Asimov formulated the three fundamental laws for robots [1], which are quoted below. The perspective here is, in contrast to the robot described by Čapek, a benevolent, good robot that serves the human being. Asimov visualised the robot as a mechanical creature (automaton) of human appearance having no feelings. The behaviour was dictated by a "brain" programmed by human beings, in such a way that certain ethical rules were satisfied. The term *robotics* was thereafter introduced by Asimov, as the science devoted to the study of robots which was based on three fundamental laws. They were complemented by Asimov's zeroth law in 1985. Since the establishment of the robot laws, the word robot has attained the alternate meaning as an industrial product designed by engineers or specialised technicians. [12, 2, 4]

0. "a robot may not injure humanity, or, through inaction, allow humanity to come to harm." [2]
1. "a robot may not injure a human being, or, through inaction, allow a human being to come to harm."
2. "a robot must obey the orders given it by human beings except where such orders would conflict with the First Law."
3. "a robot must protect its own existence as long as such protection does not conflict with the First or Second Laws." [1]

The first laws were complemented by two more laws aimed for industrial robots by Stig Moberg from ABB Robotics, presented in [9]. In the additional laws, also the motion of the robot is considered.

4. A robot must follow the trajectory specified by its master, as long as it does not conflict with the first three laws.
5. A robot must follow the velocity and acceleration specified by its master, as long as nothing stands in its way and it does not conflict with the other laws. (Translated from Swedish by the author. [9, p. 8])

2.2 The terms *robotics* and *industrial robots*

The distinction of robots lies somewhere in the sophistication of the programmability of the device – a numerically controlled (NC) milling machine is not an industrial robot. As [5, p.3] says, "if a mechanical device can be programmed to perform a wide variety of applications, it is probably an industrial robot". The essential difference between an industrial robot and an NC machine is the versatility of the robot, that it is provided with tools of different types and has a large workspace compared to the volume of the robot itself. The NC machine is dedicated to a special task, although in a fairly flexible way, which gives a system built after fixed and limited specifications [4]. [12]

The study and control of industrial robots is not a new science, rather a mixture of "classical fields". From mechanical engineering the machine is studied in static and dynamic situations. By means of mathematics the spatial motions can be described. Tools for designing and evaluating algorithms to achieve the desired motion are provided by control theory. Electrical engineering are helpful when designing sensors and interfaces for industrial robots. Last but not least, computer science provides for programming the device to perform a desired task. [5]

The term robotics has recently been defined as the science studying "the intelligent connection of perception to action" [12, p.2]. Industrial robotics is a discipline concerning robot design, control and applications in industry and the products are now reaching the level of a mature technology. The status of robotics technology can be reflected by the definition of a robot originating from the Robot Institute of America. The institute uses the definition that "a robot is a reprogrammable multifunctional manipulator designed to move materials, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks" [12, p.4]. The key element in the definition is the word *reprogrammable*, which gives the robot characteristics as utility and adaptability. Sometimes the word robotics revolution is mentioned, but it is in fact a part of the much larger computer revolution. [13]

Most of the organisations nowadays agree more or less to the definition of industrial robots, formulated by the International Organization for Standardization, ISO.

- "Manipulating industrial robot is an automatically controlled, reprogrammable, multi-purpose, manipulative machine with several *degrees of freedom*, which may be either fixed in place or mobile for use in industrial automation applications". [4, p.25]

- "Manipulator is a machine, the mechanism of which usually consists of a series of segments jointed or sliding relative to one another, for the purpose of grasping and/or moving objects (pieces or tools) usually in several *degrees of freedom*". [4, p.25]

From this definition, it can be seen that the word *manipulator* is used for the arm of the robot. The definition of *industrial robot*, it can be interpreted as follows. A robot shall easily be reprogrammable without physically rebuilding the machine. It shall also have memory and logic to be able to work independently and automatically. Its mechanical structure shall be able to be used in several working tasks, without any larger mechanical operations of the structure. [4]

Another definition comes from Japan Industrial Robot Association (JIRA), where they divide robots into six different classes. They also incorporate tele-manipulators and simple automatons, which is one of the reasons to why Japan often have hundreds of thousands of installed robots. Approximately 25 % of the installed robots can be counted as industrial robots from our point of view, which however still makes Japan the leading robot user. [4]

3 History of automation

Now we have talked about the definitions, and are prepared for a historical journey in the footsteps of robotics, starting with automation. Ever since the industrial revolution started in the 18th century, automation has been the major force when trying to rationalise the production process. Later on, with the early computers and integrated circuits, it was possible to automatize with the help of systems integrated by a central computer, and soon also with industrial robots. In order to understand the connections, some background information is given in this section.

3.1 Mechanisation and rationalisation

Until half a century ago, automation has been almost synonymous to mechanisation. The development of machinery and other technical devices replaced the manual work. The drawbacks are large costs and that the equipment are very rigid. Before producing a new product, the whole production line had to be rebuilt. This resulted in that mechanisation mainly was applied in industries having mass production, like the car industry. [8]

Many examples of automation can be found during the industrialisation, where one of the main thoughts was to automatise the manual work. From a Swedish point of view, Christoffer Polhem was an automotive entrepreneur. Influenced by the changes in the French and English metal and textile manufacturers, he constructed machines to cut out cogwheels for clocks using hydropower at Stjernsund's works. The automation of cogwheels first seemed doubtful, the clockmakers thought, because handmade products was a matter of professional pride. Polhem also constructed many other machines that rationalised the manual work, like spinning machines and rolling mills. [14]

Taylor and Ford are of course important parts of the history of automation, with their "scientific" ideas about structuring the work based on splitting the work into small, independent parts. It was measured how long time the optimal way of working was for each piece of work, and then the work methods were scheduled and planned. In Ford's factories the frames of the cars were passed on assembly lines from one station to the next and the parts were delivered on a parallel belt. Each worker took care of one or two tasks. This was criticised by the skilled workers, who experienced a decreasing demand in their jobs and for them the job was boring. Therefore, a large problem was the huge exchange of personnel. [14]

3.2 Birth of computers and integrated circuits

Herman Hollerith, see Figure 2, is another person who is important for the history of automation and implicitly also robotics, because he brought the birth of the computers. In 1886 he introduced a punch card machine for the population census. The cards had holes and "non-holes", and when the cards passed over a metal surface, wire brushes found their way through the holes and closed electric circuits. Using this invention the results of the American population census in 1890 was not counted by hand for the first time. Later, the invention of Hollerith was a basis for the foundation of the computer company IBM. [14]

The digital computer in the 1950s and the integrated circuit in the 1970s were two inventions who steered the manufacturing technology onto a new shift. Before, only the material-processing system was improved. With the computer age it was also paid atten-

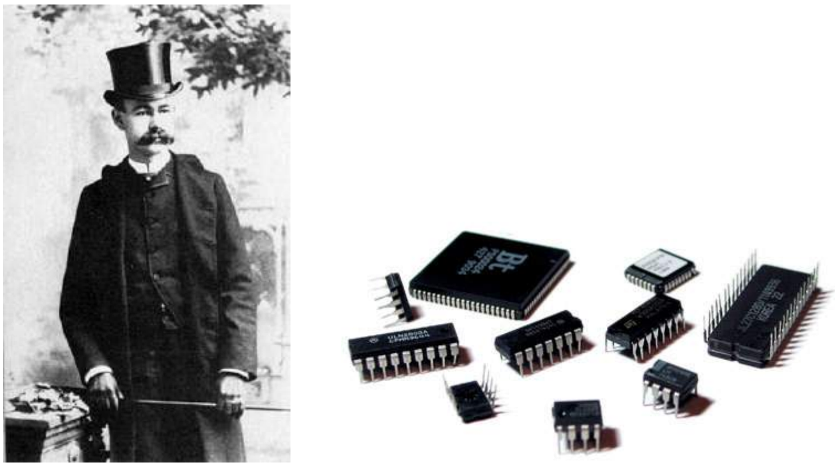

Figure 2: Portrait of Herman Hollerith (left), and a picture of some integrated circuits (right). [10]

tion to the information-processing system in the rationalisation and improvement work. While the mechanisation is suited for large-scale production, the computer technology can in general be applied to all industrial activities. The production can be made more flexible, and it is nowadays also worth automatizing the large-scale production and still obtain flexibility in the production. With the help of the inventions, more and more machines were equipped with increasingly sophisticated digital control units. In the beginning the machines were stand-alone, but in the late 1960s, systems started to be integrated with each other by a central computer. [8]

With the development of the early computers, it was possible to develop "the brains" of the industrial robots. When more powerful computers with integrated circuits were developed, it facilitated the robotics development even more.

4 The early steps of industrial robots

While the prerequisites for the industrial robots to appear are the automatisation and the computers, the idea of robots has another origin. Here, the antique automatons play an important role, which is explained in this section.

4.1 From antique automatons to NC machines

The thoughts of an industrial robot, or at least human-like creations or automatic devices to serve humans, has existed for a long time and they have been documented in myths, stories and tales. Some researchers mean that it all begun with the playful engineer Heron, who came from Alexandria and lived in the first century BC. Some of his ideas was to automatically open the doors of the temple using the energy coming from when the altar fire was lit, and a device that transformed steam into a rotational movement. [4]

The earliest applications of robot mechanics (automatons) originated, like Greek drama, from liturgy. One explanation to why this work did not continue, was that Greek science as a whole did not value practical applications. The socioeconomic mechanism that rewarded practical scientific work simply did not exist. Later, in the 9th century, the Khalilf of Baghdad decided to collect all the Greek texts, which had been preserved by monasteries and scholars during the fall of western civilisation. It resulted in the book "The Science of Ingenious Mechanisms", where over hundred devices were described and depicted. The Arabs were interested in manipulating the environment for human comfort, and not only in dramatic illusion like the Greeks. Therefore, the main contribution to these texts was the concept of practical application. [4, 11]

The Renaissance brought new interest in Greek art and science, and Leonardo da Vinci was one among the interested intellectuals. He tried to verify the Greek constructions and to complete the thoughts. The construction of mechanical automatic machines then had its culmination in the 1800th century, when Swiss craftsmen built a number of automatons (older word for robot, meaning objects that move automatically) designed like human-like dolls. Mechanical works made them act very naturally, among the most famous are the Scribe, seen in Figure 3, the Draughtsman and the Lady Musician. Until now only automatons for joy and entertainment have been described. However, these are an important part of the automatic machines in industry, since they challenged the limits of the technique and mechanics. [4]

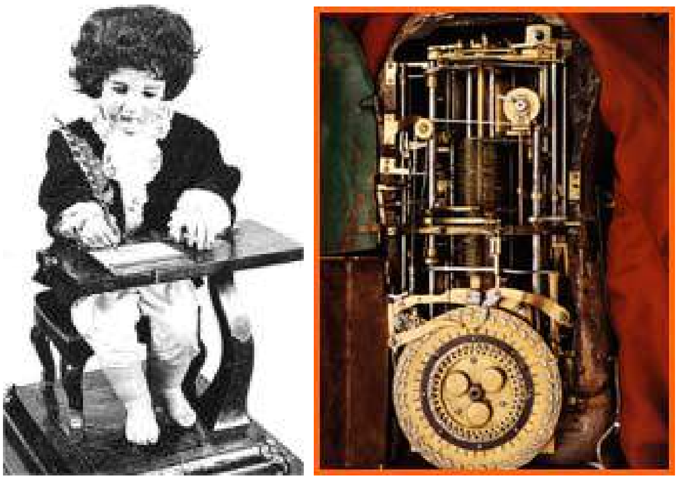

Figure 3: The Scribe and its fascinating mechanism.

One who in turn was inspired by da Vinci in the 20th century was Nikola Tesla. He had an industrial focus and was one of the greatest inventors of the industrial revolution. One can also say that he made pioneering works in robotics by his robot boat model. Tesla was also one of the first who saw the direct analogy between machines and man in their mechanisms, senses and control. He thought of robots not as toys, but as the complex integrated systems they are. [11]

The hydraulic assembly machines and the numerically controlled turning and milling machines, also called NC machines, arrived in the 1950s. The first advanced NC machine was presented at MIT in Boston 1951, and the Swedish descendant J. Parson led the development. The NC machine was programmed using only numbers, and it could easily be reset for short series. It that sense the NC machine was a technical breakthrough, and from now on it was possible to work with more advanced designs. With the birth of the computers, the computer numerical controlled (CNC) machines came, see Figure 4. Technically, you can say that the industrial robots originate from two different machines; the hydraulic assembly machines and the NC machines. [14]

Figure 4: An example of a computer numerical controlled (CNC) machine. [10]

4.2 A robotic embryo

During a cocktail party in Connecticut 1956, the embryo of an industrial robot was possible to perceive. One of the guests at this party was George Devol, who two years earlier had written a patent on a machine called a Programmed Transfer Article. He was however uncertain about how the machine actually could be used. The other guest was Joseph Engelberger, an space industry engineer very fond of science fiction and the books of Isaac Asimov. This meeting resulted in the company Unimation, development of the Unimate robot and the birth of the industrial robot industry! They complemented each other very well, the entrepreneur Engelberger and the innovator Devol. [14]

First they visited 15 car factories and around 20 other industries to better understand the needs regarding industrial robots. Then the prototype came in 1961, and the first robot was installed in General Motor's (GM) factory in Trenton to serve a die casting machine. It was a fairly simple robot, compared to the one you can see nowadays, because they could only perform one task. The life-span was expected to be 18 months, and since GM wanted to be able to pay-off the robot in 18 months, it was sold for 18 000 $, but however produced for 65 000 $. Unimation sold it cheap because it was used as a reference object. To increase the demands on robots even more, Unimation desired to initially hire out the machines, which turned out to be a successful move. [14]

4.3 The first robots installed

The technical director at Ford, Del Harder, was an important man when it came to technical development. When he said that Ford was interested in installing 2000 Unimation robots in their factories, it was an important step. In order to increase the production he shamelessly copied the Unimation robot specification and sent it to other companies for production. That movement made a large number of American companies entering the robotics industry and they also saw the potential of the industrial robot. [14]

After installing 66 robots for GM at their new factory in Ohio, the breakthrough of the industrial robot had come. The demand for robots was still weak, but Unimation now was convinced that the industrial robot had a future. They just had to wait until the market was ready for them. If the manufacturing industry was not very interested in robots, media was the opposite. Engelberger and his robots were regular guests on the

American television, where robots served coffee in shows and beers in commercials. The robot changed from being a scary object to a "funny toy" to the general public. [14]

In Sweden the first robots were installed in 1967 at Svenska Metallverken in Upplands Väsby, and they were actually also the first ones in Europe. The robots did monotonous jobs like picking in and out. In 1969 Unimation installed its first robots for spot-welding, it was 26 robots for spot-welding car bodies at GM. In 1972, Europe followed by setting up a spot-welding line with robots at Fiat. [14]

4.4 Building up the industrial robot industry

We have already seen that the first commercial use of industrial robots trace back to the beginning of the 1960s. But it was not until the middle of the 1970s the industrial robot industry could be seen as a separate unit. The results of the research and development period 1960-1975 began to be ready for commercial products. New microelectronic components, especially the microprocessor, came and formed the basis of the powerful and cost-effective control systems of today. The potential users also had time to assess the new technology and its use. Installing robots in the production was also a result of the increasing oil prices and the competition from companies around the world. Since the second half of the 1970s, the sales of industrial robots has grown very rapidly and the average of the yearly growth exceeded 30 %. [8]

However, the first application where the robot took part and where used instantly in the working process was spray painting. The Norwegian company Trallfa producing wheelbarrows needed some flexible spray painting device, due to the bad working environment and thereby difficulties to recruit new personnel. To install a Unimate robot would cost 600 000 Norwegian crowns, and Trallfa then came up with the idea to try to develop a cheaper robot for their own spray painting applications. The goal was to keep the cost under 15 000 Norwegian crowns. After a few years of development, they could in 1967 present an electro-hydraulic robot which could perform continuous movements and also was very easy to program. The robot was meant for their internal use only, but developed into a commercial success. In 1985 ASEA (later ABB) took over Trallfa, and the painting robots and ASEA's industrial robots complemented each other well. [4, 14]

This is only one example, however maybe one of the most successful, of large companies developing their own industrial robots in the end of the 1960s and during the 1970s. Electrolux, ESAB and Atlas Copco are some Swedish examples. Some of them then merged with ASEA in the first part of the 1980s. [14]

As an example of the industrial robot production, one can mention the year 1973. There were 3000 robots in operation around the world and 30 % of them were Unimation robots. 71 different companies manufactured industrial robots at that time. However, the usage of robots in the industry increased only slowly in the beginning. For example, Unimation did not show positive figures until 1975, 14 years after its creation. [14]

4.5 ABB and their IRBs

ABB deserves some attention. They started their robotic career by using NC machines in the 1960s and after a couple of years, they became the largest user of NC machines and advanced production techniques in Europe. ASEA had its own development and marketing of NC control systems, which became a forerunner to their robot control systems. When using Unimate robots in the production from 1969, they saw the great potential of industrial robots. ASEA was interested in manufacturing Unimate robots on license, but since Electrolux became the sales representative, ASEA decided in 1971 to develop their own robots instead. After broad tests of different concepts, they decided for an electrically driven robot. The control program of the first prototype of the robot, named IRB 6, fitted in the new Intel 8008 based microcomputer in 8 kb. Due to the limited space, the program was extremely compressed and complicated. The Intel microprocessors had been flown from Intel in USA, and they were in fact the first microprocessors used in an ASEA product, and also the first chip that Intel had ever delivered. The robot incorporated some new technical features; a fully electrical robot (both the drive and the control systems), an anthropomorphic structure of the robot and it was one of the first robot to be controlled by a microcomputer. The introduction of microprocessors in industrial robots was an important technical breakthrough. [14]

The first customer of IRB 6 was not, as one may think, a large company, but instead Leif Jönsson at Magnussons i Genarp AB. It was a small firm with 20 employees producing stainless steel pipes for the food industry. By the help of an industrial robot, Magnussons was one of the first in the world to operate an unmanned factory around the clock, seven days a week! The next model IRB 60 was introduced in 1975, and both IRB 6 and IRB 60 were included in the ABB product range for 17 years, which is something of a record in industrial robot circles. [14]

5 Further robotic development

The robots have undergone a huge change since the first prototypes. In this section some of the main developments are described.

5.1 Robotics in the late 1960s and the 1970s

The first industrial robots were pneumatic or hydraulic. In 1968 the electric robot Vicarm came. Studies by GM regarding how robots and humans could work together on the assembly line showed that 95 % of the parts of a passenger car had a weight between 1.5 and 2.5 kg. The pneumatic and hydraulic robots were intended for much larger loads, and therefore not suited for assembly works. The niche was perfect for the faster nut not so strong electric robot. One of the first programming languages for robots were also written at that time, by a colleague to the innovator of the robot Vicarm. [14]

The first microcomputer controlled robot was introduced by Cincinnati Milacron in 1974, called T_3 – The Tomorrow Tool. It was an important venture that echoed throughout the whole industry, since Cincinnati Milacron was the largest machine tool constructor in the world. Volvo gladly used Unimation robots, but after the introduction of T_3, they invested in a number of such robots in the factories in Torslanda and Olofström. The robot division of Cincinnati Milacron was in 1990 acquired by ABB. [14]

5.2 Robotic challenges in the 1970s and 1980s

Material handling, the main area for robots in the 1970s, required sufficient load capacity of the robot. Arc welding on the other hand, required better motors and control systems to manage the path control. In the end of the 1970s and the beginning of the 1980s the development was mainly concentrated on assembly. Thereby robots with higher repeatability, acceleration and velocity were needed in order to shorten the cycle times. [4]

The automotive industry was, and still are, an important customer, but also metal industry with their heavy, hot and inhospitable working environment. In the 1980s relatively simple tasks, like machine tending, material transfer, painting and welding were economically viable for robotisation. [5, 13, 4]

Especially in the first half of the 1980s, enormous interest was focused on industrial robots. Industrialists, researchers, politicians and journalists all identified robotics as a key area to support industrial development and achieve increased competitiveness. [8]

The development from the latter part of the 1980s until now has involved advanced sensors. In special applications machine vision, laser scanners or force sensors are needed to be able to detect and follow the parts of the object. The sensors need to be integrated with the control system of the robot, since the sensor and the robot shall work together. One possible research direction is towards a more open interface in the control systems, which facilitates for a broader range of sensors that can integrate with the robot system. [4]

5.3 Wide-spread robots

One can really say that the robotic revolution has come, when the figures of the operational stock of industrial robots are studied in Table 1. It shows the stock for selected countries around the world the year 2005 and the facts originate from the International Federation of Robotics (IFR). The figures has to be accepted with some reservations,

Table 1: Operational stock of industrial robots for selected countries the year 2005 [7].

Geographic area	Quantity
Africa	**634**
America	**143 203**
North America (Canada, Mexico, USA)	139 553
Asia/Australia	**481 664**
Japan	373 481
Republic of Korea	61 576
Taiwan, Province of China	15 464
China	11 557
India	1 067
Europe	**297 374**
Germany	126 725
Italy	56 198
France	30 434
Spain	24 081
United Kingdom	14 948
Sweden	8 028
Denmark	2 661
Norway	811

since different countries can have slightly different definitions of industrial robots as was discussed earlier. For example, Japan also counts simpler mechanical machines as industrial robots. However, Table 1 shows that Japan is still the largest user of industrial robots in the world, followed by Germany.

6 World-wide debate on automation and robots

Robotisation has been a controversial subject for a long time. The machine is surrounded by a scaring atmosphere and is totally different compared to what we have seen, which naturally gives rise to discussions. How will the robots affect our lives and our working life?

6.1 Automation

In 1946 Del Harder became technical director at Ford, which aimed for developing a completely automatic production line. Soon the company had an automation department working on how to optimise the use of equipment and increase the productivity. The ventures of Ford led to a world-wide debate on automation. The critics thought that automation was designed to rationalise the workers out of production and they were afraid of mass unemployment. On the other hand, the supporters believed in that automation would lead to a "second industrial revolution". At that time it was a strong skepticism towards more and more advanced machines. This is maybe one explanation to why Harder himself never used the word "robot" for the rationalisation process in his enterprise. [14]

6.2 Unemployment and education

When discussing social impacts of robotics, unemployment is one of the main arguments. However, the connections between unemployment and robots is not yet well understood. Productivity improvements resulting from the usage of robotics in the production can affect labour in many ways. It depends on factors like effects of new technology on the relative proportion of machine to workers, the extent of change in prices and production volumes when the new technology is used, and the supply of qualified workers with specialised knowledge. Like productivity, unemployment can be defined in many ways and is the result of a variety of events, which complicates the discussion even more. For the single worker, the increased usage of robots in the production may lead to unemployment. On the whole, the robots can however bring new technologies and develop the industries towards other areas which may create new jobs. [6]

Robots require workers who have a technical understanding. Already in 1983 one could see a shortage of labour in many fields of engineering and science, especially in areas of computer software design and programming [6]. It is advantageous if the workers themselves can instruct, oversee or repair the robots. To be able to do that, they need basic understanding of mechanical and electrical systems – the key words are retraining and reeducation. Besides that, a well-educated worker is easier to retrain to another job in the plant. One rather important effect is also that technologically educated workers may show less opposition to introduction of robots and other automation techniques. This last factor may be one of the reasons to why Japan seems to welcome so many robots in their plants. Japanese employees are in general highly technical educated. [6, 3]

One cannot forget maybe one of the most important reasons to why robotics knowledge is essential. The laws of robotics, presented previously, is not built in the robots of today, because they are not still advanced enough. One must remember that the robots are considered as inanimate and irresponsible and the human running the machine has the responsibility. This requires knowledge. [3]

6.3 Working environment

When discussing the impact of robotics, quality of the working environment is another issue. Many of the robots installed have taken over hard, boring or dangerous work. If the new jobs created by robotics are better, then the quality of working life will of course be improved. When robots do the simple, boring tasks, the worker can have a job with more variation and may, for example, be responsible for a larger part of the production line and use more of his or her skills.

On the other hand, some experts argue that if the human being is a part of a more mechanised environment, it will "deskill" labour and require less competence. The never-ending discussion about the relationship between employer and employee is actual also here. Robotics can, as in the case of the industrial revolution, be seen as a way to get rid of troublesome labour. [6]

6.4 The vision of productivity

The vision of robotics has changed over the decades. In the early 1980s industrial robots were seen as the ultimate solution to automatized factories. The robots were the symbol for the whole area of factory automation, where entire factories would require few, if any, human workers [8]. Why did not these visions came true? One answer stated in [13] is that robotics is difficult, or that humans themselves perform their very jobs well. Automation is not only dealing with removing all workers and replace them by robots at the assembly lines, because it highly involves problems with integration of complex systems. Often the development and design cost of the entire workcell outperform the cost of a worker, except for relatively simple tasks like spot welding, spray painting and palletising.

The industrial robot has often been ascribed to automatically bring productivity. In [6] it is warned about making simplistic assumptions that exaggerate the importance of robotics. Robotics is only one part of many technologies that are available to automatize and improve the production. The concept "productivity" is subtle and complex, and it also has several meanings and can be measured in many different ways. The productivity also relies on many factors that interact with each other, and therefore the robots alone (or any other technology alone) cannot improve the productivity. [6]

In total, it resulted in a decreasing interest in robotics in the late 1980s. Robots are nowadays developed for not only manufacturing, but also medical tasks, search and rescue, entertainment and service, which brings new interest in robotics. By that, robotics can be seen as a part of the larger field of mechatronics, which is an integration of mechanics, electronics, control and computer science. It that sense, a robot is the ultimate mechatronic system. [13]

7 Summary

In this report some phenomena and events in the history of industrial robots have been described. The prerequisites are mainly the early automation in the industry, together with the playful automatons. With the computer and later on the integrated circuit, it was possible to develop the first industrial robots.

The first robots were used for simple tasks as pick and place, since they had no external sensing. They replaced humans in monotonous, repetitive, heavy and dangerous tasks. When the robots could manage both a more complex motion, but also had external sensor capacity, more complex applications followed, like welding, grinding, deburring and assembly. The usage of industrial robots can nowadays, roughly speaking, be divided into three different groups; material handling, process operations and assembly.

In general, industrial robots are used to reduce costs, increase productivity, improve product quality and eliminate harmful tasks. These areas represent the main factors resulting in the spread of robotics technology in a wider and wider range of applications in manufacturing industry. However, introducing robots do not solve all problems. Automation, productivity, employment are complex questions and the connections between robots and labour can be discussed much more.

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Sammanfattning
Abstract

In this report some phenomena and events in the history of industrial robots have been described. The prerequisites are mainly the early automation in the industry, together with the playful automatons. With the computer and later on the integrated circuit, it was possible to develop the first industrial robots.

The first robots were used for simple tasks as pick and place, since they had no external sensing. They replaced humans in monotonous, repetitive, heavy and dangerous tasks. When the robots could manage both a more complex motion, but also had external sensor capacity, more complex applications followed, like welding, grinding, deburring and assembly. The usage of industrial robots can nowadays, roughly speaking, be divided into three different groups; material handling, process operations and assembly.

In general, industrial robots are used to reduce costs, increase productivity, improve product quality and eliminate harmful tasks. These areas represent the main factors resulting in the spread of robotics technology in a wider and wider range of applications in manufacturing industry. However, introducing robots do not solve all problems. Automation, productivity, employment are complex questions and the connections between robots and labour can be discussed much more.

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