

FOURTH INDUSTRIAL REVOLUTION. ROBOTS AND PRODUCTION AUTOMATION WITH ELEMENTS OF ARTIFICIAL INTELLIGENCE

Prof. Pavlov, V, Phd¹, Avishay, D. Phd², Pavlova, G¹
 Technical University of Sofia, Sofia, Bulgaria¹

Afeka, Academic Engineering College in Tel Aviv, Department of Mechanical Engineering, Bnei Ephraim Street No 218 - Israel
 vpavlov@u-sofia.bg, davishay@afeka.ac.il, raicheva@tu-sofia.bg

Abstract: The present research is devoted to the coexistence and communication of a person with machines, equipment and robots that possess elements of artificial intelligence. The new conditions lead to revolutionary changes in the automation of various activities in and outside the industry. Changes are multifaceted and the disclosure of trends allows planning and protecting of legal long-term activities to achieve useful outcomes effectively.

Keywords: Industrial revolution, robot, artificial intelligence, person, coexistence, automation, education, selftraining

1. Introduction

1.1. Motives for the Human Society Development and Revolutionary Steps

The evolution of human society creates tools of labor to satisfy ever-increasing needs of the people. The man kind are forced to create tools that initially were driven by the energy of their muscles. Subsequently, the mental development is directed to the use of other kinds of energy – directly the natural (the power of water, fire, wind) and later - other types (electricity and other). The essence of satisfying human needs (consumption) most accurately and briefly is defined in the theory of Abraham Maslow [1], an American scholar psychologist in the publication „A Theory of Human Motivation”, He defined the needs of humans as a hierarchical pyramid (fig. 1).

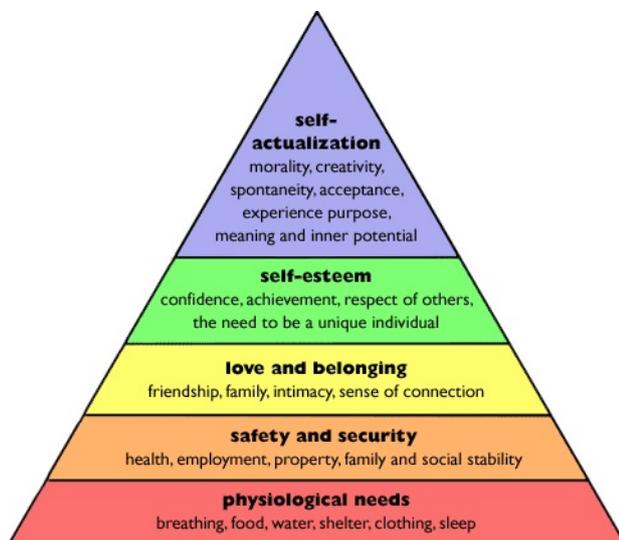


Figure 1: Distribution of needs according to Maslow's pyramid

According to Maslow, if the lower-level needs are not met, the person can not focus on fulfilling higher level needs. If the hierarchical structure of the pyramid is considered in detail, the importance of technological evolution with appropriate tools could be determined. As we progress to higher levels in the pyramid it could be seen how consumption increases. The hard to satisfying human nature

drives him from what he has got, to what he has not or has not yet achieved. Passion for prey and survival tolerates violence The warriors have created and perfected instruments (armaments) for years and centuries. When neighbors are conquered, the distant countries become a next/new goal. Expanding their territories and conquering the peoples, the economically developed countries - conquerors, draw resources and goods from conquered territories and increase their wealth. As a result, a society with distributed functions and migration of the Earth population from poorer to richer countries is created. The number of people in the world is increasing and most often in less developed countries and the basic needs of these people are growing. Economically, the society is oriented towards change and modernization. The purpose of change is to give hope for the future. Society has reached its inflexion point. The change is revolutionary. The revolution comes to satisfy the increased consumption and is based on one or a group of discoveries.

1.2. Characteristic features of industrial revolutions

As a beginning of the industrial revolution (IR) is considered:

- for the first IR - invention of the steam engine, as well as improvement of the weaving and spinning looms;
- for the second IR - invention of electricity, the internal combustion engine, the radio and the production line;
- for the third IR - the emergence of: electronics, robotics, computer chip (microprocessor), flexible automation, new materials, information and communication technologies, Internet.

Recently there is a change in economic reality and political authority [2,3,4], which is considered as the fourth industrial revolution. The "country and market behavior" is the main topic that was discussed at the World Economic Forum in Davos in 2016. There is growth of convergence between three spheres - the techno-sphere (the digital world and everything materially created by humans), the natural world (the eco-sphere) and the human sphere (socio-informational, everything not material created by people). A new point in the interconnection and interaction between man and machinery accrues – people and robots are allowed to work together in one job (place), as well as different machines (robots) and people from different cultures (multicultural). The relationship between physical, digital and biological systems (bioengineering) is developing. This new stage of the economic development is based on: new

technologies, AI robots, 3D printing (4D printing, for now is modestly mentioned, but in the near future it is expected to create structures, that can "grow in time", by analogy with biological ones), nanotechnologies (including nanorobots), big data processing (super intelligence), and AI-based automation. The speed with which the world is developing is unprecedented. The future comes soon and this imposes new demands on education and training of people [8,9] because of coexistence and action with robots with artificial intelligence.

2. Artificial intelligence and robots

The first obstacle encountered by technological revolutions is the need for qualified specialists for the new type of work. The new professions set different conditions

from the previous ones. The intellectual human potential, allowing quick adaptation to the new, is still limited.

This gives the opportunity of biological species to survive (providing food and nutrition, surviving in a dynamically changing environment, and procreation through breeding), and people and human society, that in addition to the three activities for survival also needs spiritual life, to reach the current stage of development.

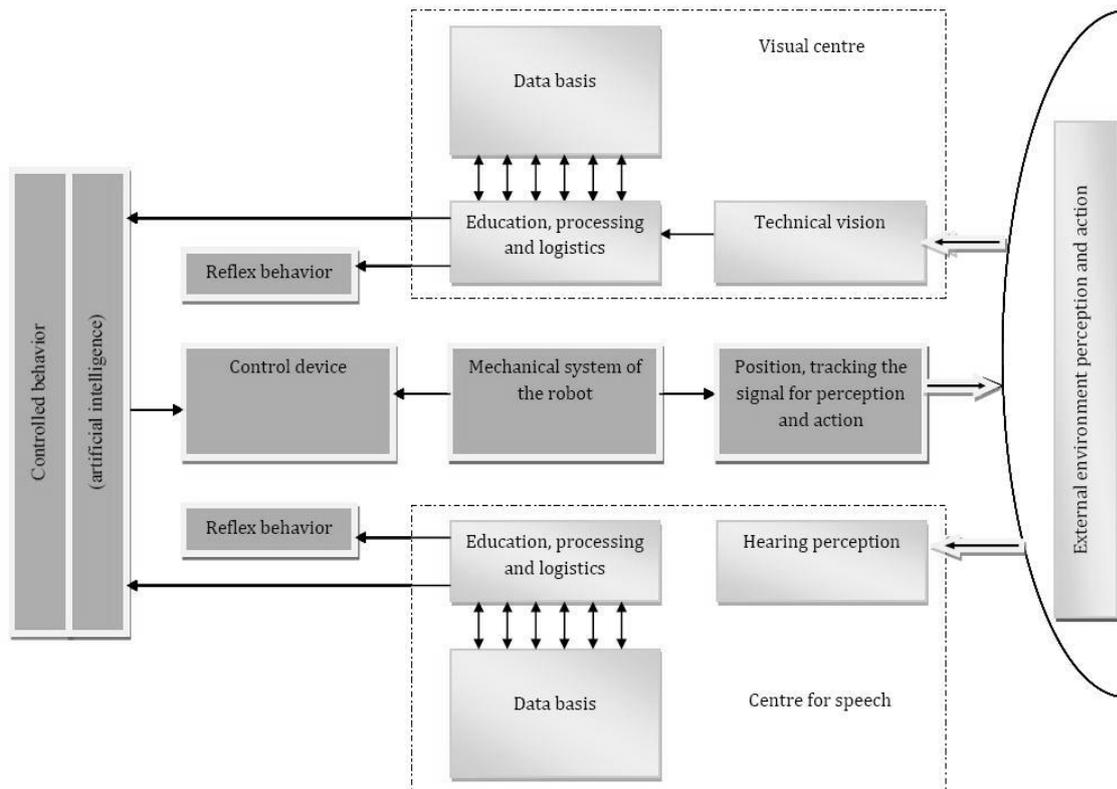


Figure 2. Architecture of robot with artificial intelligence

By analogy with the natural intelligence of humans and living creatures, inhabiting our planet, artificial intelligence (AI) is created due to increased abilities of computer technologies to solve complex tasks not only in the industry but also in the intangible sphere. The new digital environments are constructed by analogy to the biological world and are defined as artificial intelligence systems (AIS). In the architecture of the robots with AI (Figure 2), units for perception of the external environment must be included by analogy with the human brain and sensory organs, that allow solving tasks using global databases and knowledge (cloud technologies and super computers) [10]. This makes it possible for people and robots to work together (at the same workstation without collisions), which on the other hand reveals new opportunities in automation in the industry and beyond.

Robots nowadays are a product based on the latest physical theories, mechanical and physico-chemical technologies, theories and techniques for assessment of their

own state and perception of external environment, technologies and techniques for collecting and processing of information and forming controlled behavior, including elements of AI. But in the near future, a qualitative change in intellectual capabilities is expected. New means for obtaining and transforming energy are expected. Such a product implies a need for knowledge in many scientific fields. Bionics and cybernetics are the theoretical basis of robotics. Biomechanics (integration of biology, mechanics and electronics) is the future of robotics. This integration has appeared in the form of "Biologically Inspired Robots". For entrepreneurs, the dilemma "man or robot" will stand, as their qualities will get closer and in most cases the comparison will be in favor of the robots.

On one hand, human uses biological (zoological) analogies to improve the robots, and on the other hand man (and in the future, animals) has to be artificially "repaired" by implanting (including "added intelligence"). While, on the one hand, scientists (biologists and doctors) are progressing

rapidly on the way of "humans robotisation", scientists-engineers are running along the same way striving to "humanize the robots". While the "artificial man," replacing human parts with artificial ones is creating, robotics aims to create a robot with artificial intelligence. The result of these efforts will occur at the so-called singularity point. According to the latest forecasts, a complete "technical singularity" will occur in 2045, i.e. the Turing test will be passed by computer, although according to some authors [7, 8], now there are partial cases of passing the test.

Thus, two tendencies are emerging for the future development of robotics: fear (robo-fear) and hope (robo-hope). What are the aspects of "human fears"? A lot of researchers believe that the three leading technologies for the 21st century are now unpredictable - robotics, genetic engineering and nano technologies.

They may be far more dangerous than previous technologies in the 20th century because a 20th-century bomb may explode "only once", but for example a reproductive robot may "get out of control" and to reproduce through multiplier technology "countless" copies of himself. The danger of the new technologies of the 21st century is that they are based exclusively on knowledge and do not require heavy equipment, rare raw materials and large capital investments. For this reason, both positive (beneficial) and negative (harmful and dangerous) technological products could be created by a smaller group of people. However, humans and, above all, the government elite of the states have to be prepared to avoid of harmful products and the negative consequences of the development of the leading technologies of the 21st century. Actually, as the bombs of the 20th-century have failed to destroy population, human society and the nature of the Earth, the negative consequences of new technologies in the 21st century could be possible also to be prevented. Since the fourth revolution concerns the highly developed countries (there are places on the Earth where they have not passed the first three stages), we must hope that they will not allow human society to be restarted from the beginning (from the primitive).

What are the optimistic forecasts?

- Robots have a great merit in the development of industrial technologies and technology in turn contribute to development and improvement the quality and ability of the robot;
- Robots gradually become indispensable and excellent assistants in the lifestyle of people, for example in the performance of precise and complex surgical operations (telecontrolable robot Da Vinci, cyber knife, etc.);
- Robotics provides modern adaptive and intelligent dentures, orthoses (mechanical compensator for physical disabilities), artificial limbs and artificial organs;
- It is possible to implant the robot-technical components in a person's body, which is related to the idea of turning people into "robot people", i.e. in cyborgs;
- Robots help people and society to fight terrorism, crime and road accidentst;
- Robots create new jobs - directly and indirectly.

3. *What kind of changes could be expected in automation*

Modern society is at a stage of immense automation, that undoubtedly increases the productivity and quality of human activity. Essential criteria for modern automation in industry is flexibility - the ability without reconstruction to produce new products. Productivity and versatility are the antithetic features. The highest productivity can be obtained when the versatility is low (zero) and vice versa. The highest productivity comes from a fully-organized work environment that accurately determines all the elements involved in the manufacturing process (machines, basic and auxiliary equipment, robots, billets, details, assemblies and finished products) in space and time. The rhythm of production, if it is not the same or continuous, imposes intermediate storage in specialized facilities (intermediate warehouses). In order to shorten the transport times, the ordering is by the sequence of the technological process (less often by group technology). The efficiency of all devices for the highest productivity is when they are developed for the specific production, which is contrary to the flexibility.

The flexibility is imposed due to the individualization of consumption and, in particular, due to the constantly increasing requirements for the realization of the production on the market. The competitive environment requires offering new products with improved quality and competitive price. That is why an optimal and dynamic ratio between productivity and flexibility is needed and the change is in favor of flexibility.

The digitization of machinery and equipment, the new technologies, newly discovered materials and modern science dynamize industry and modern society. Metaphorically, the automation could be presented as an "orchestra with conductor artificial intelligence" to obtain a finite intelligent product. The robots in industry called "industrial" or "stationary robots" are used to fulfill their assigned functional task - to perform both technological (welding, painting, cutting, etc.) or ancillary (moving of blanks and finished parts, tools, equipment) operations. Therefore, the movements, actions and intellect that they have to possess are related to the respective task. They replace a man-worker with a robot-worker, and it is logical for these robots to be called "technological robots." The next higher level of robots, which will have a more developed AI, will cover a certain specialization like human engineers and will be a robots engineer-specialist. This class of specialized robots could be used not only in industry, but also in the automation of all human activities, which will ensure high quality and precision of the execution processes. All this is a prerequisite for a new organization of automation - from a fully organized environment that requires a large number of auxiliary equipment, specific for each product to semi-organized one, where the production object (another type of product) occupies one of the possible stable positions and the position could be changed over the time.

There are still hypotheses about the spheres and / or segments where the fourth revolution will find a field of expression and to what extent the production will change. Bold is the forecast of Chief Executive Officer of AutoDesk, Carl Bass, "future factories will have only two employees: one man and one dog. The work of a man will be to feed the

dog, and that of the dog - to prevent the person from touching the equipment. "

Of course, it should be have in mind that AI (for now elements of AI are considered) can not fully cover the creative abilities of the human individual.

4. Education of people and robots in the new situation

4.1 A mix between traditional education and open education methods of people

Nowadays there are no boundaries for information due to the internet, so the need for education in general could be reconsidered and organized in different way. The physical boundaries are no longer barriers for education due to the nationally and globally enlargement of networking services.

A modern approach in education is open education, which is one of the greatest challenges for future of learning. One of such type of education is Massive Open Online Courses (MOOCs). Except traditional course materials such as filmed lectures, readings etc., MOOCs provide interactive user forums among students, professors, and teaching assistants. The number of participants has doubled in 2015 from 16-18 million students to 35 million students across all MOOC providers.

The mix between MOOCs and traditional education methods in the future can provide higher education institutes and universities the opportunity to expand services to offer credentials using the experiences of the lecturers and teachers from all over the world.

4.2 Education of robots

Training of specialists in robotics is conducted nowadays. Here is paid attention of the need for another type of training for robots and people who train robots. Robots will receive hardware and basic knowledge from manufacturers, but they will not be enough for effective usage. Both people and robots have to go through specialized training to solve "class problems". At this stage, a bold prognosis is to talk about "schools and teachers for robots" but in the near future the need of such schools will grow up. The robots that could reproduce themselves will have very high basic capabilities of their "memory", which have to be "filled with knowledge", according to the needs of using the newly created product. By "image and likeness of its creator," the robots will have to resemble their "parent", but the knowledge about the surrounding environment and what is its job to do, the robots must acquire these knowledge through education and self-education. A rough analogy for this process can be made with modern computers. The manufacturer installes only the basic software and each user adds software and knowledge (accumulates knowledge) according to what they need to solve a certain set of tasks. If necessary, the hardware of the computer is upgraded, but the activity of the computer is mostly determined by the specificity of the software and by the knowledge of its full use, which so far remains only for the humans. It is often necessary to use the services of specialists when something unusual happens to particular computer, both with its software and hardware. The memory of robots in the near future, as well as of future computers, will probably be built

on another basis (physical, biological, or a combination of both), and will be with grater abilities.

By analogy with education of people, robot training stations can once again be called "schools", and specially educated people will be called "teachers" or "roboteachers". It is not possible for the robots to adopt the other analogue referring to the conventional modern technique. The places where the technique is repaired are called "repair shops," and people who carry out this activity are called "masters" so far. The reproductive robots will need not only simple repairs but also for obtaining new knowledge that will not only be done by changing programs, but in ways that resemble human learning, such as MOOCs modules.

5. Conclusion

The development of human society is becoming more dynamic. The future comes soon and often people are unprepared in many directions. People have long been cohabiting with machinery and equipment, but in the near future **these** devices will have intellect and communication shoul be realized in an different way. This is large extend concerns communication between a human and a robot in jointly performing different activities within and without of the industry. That is why it is necessary to create united creative teams for project development, preparation of new type of specialists with higher and secondary qualification. Legislative changes will be needed to avoid conflicting situations during design and usage of innovations to solve the problems for the benefit of man and human society.

6. References

- [1] A.H. Maslow, A Theory of Human Motivation, Psychological Review 50(4) (1943):370-96.
- [2] Клаус Шваб, Четвъртата индустриална революция, Хермес, 2017.
- [3] Хр. Проданов, Щрихи от политическата икономия на четвъртата индустриална революция, Икономически и социални алтернативи, брой 4, 2016.
- [4] Четвърта Технологична революция – Роботи & Хора.....или Роботи vs. Хора (продължение), SIS investment intermediary, 03/10/2016
- [5] Tim Urban The AI Revolution: The Road to Superintelligence, January 22, 2015.
- [6] <https://www.class-central.com/report/moocs-2015-stats/>
- [7] Kevin Kelly, Out of Control. The new biology of Machines, Social Systems, and the Economic World. 1994
- [8] Dominik B., O. Boesl, Bernd Liepert*, 4 Robotic Revolutions - Proposing a holistic phase model describing future disruptions in the evolution of robotics and automation and the rise of a new Generation 'R' of Robotic Natives, IEEE/RSJ Intern.l Conf. on Intelligent Robots and Systems (IROS) Daejeon Convention Center October 9-14, 2016, Daejeon, Korea
- [9] The Robotics Revolution: The Next Great Leap in ... – CIRCABC
https://circabc.europa.eu/.../BCG_The_Robotics_Revolution_Sep_2015_tcm80-197133...Sep 3, 2015
- [10] What role will education play in the Fourth Industrial Revolution?
<https://www.weforum.org/.../what-is-the-fourth-industrial-revo...>
- [11] Pavlova, G., V. Pavlov, R. Trifonov. Technical Parameters Integration of Mechanical and Computer Systems in Robotics; Proc. of VII International Scientific Conference Computer Science'2015, 8-10 September 2015, Duras, Albania, pp. 274-279, ISBN: 978-619-167-177-9