Chapter 6

Robotics and Other Technologies in the Cybernetic Revolution

1. Robotics as a Direction in the Development of Self-Regulating Systems

The concept of robot is very uncertain since today computer programs, manipulators, and other mechanisms, as well as human-like autonomous devices can be called a robot. But despite such a variety, a number of the main characteristics of robots of all types can be defined. It is of special importance for us that these characteristics coincide to a large extent with the characteristics of the Cybernetic Revolution and its technologies. First of all, an ideal robot (which can move, work and solve problems depending on the situation, as well as to meaningfully communicate) is a good example of a self-regulating system. It also visually reflects concrete manifestations of the main cybernetic categories, namely: active information processing (its receiving, analysis, distribution, transformation, *etc*.), management of the whole system (and of other objects) by means of information, flexible interaction with environment, existing contours of direct, and feedback links that allow fulfilling various functions. Many definitions also emphasize the aspiration to treat robot as a self-regulating system. For example, *robot is a device capable to move independently in space, to cope with tasks of picture recognition and analysis, possessing a large mobility, able to analyze a situation by means of feedback and also to predict situations, relying on its own experience and available information* (definition by Professor Shigeru Vataat, see Nakano 1988: 26).

1.1. Robotics at the modernization phase of the Cybernetic Revolution

The initial phase of the Cybernetic Revolution convincingly showed a powerful rise of the new branch of robotics; thus, hardly anyone doubted the promising prospects of its development as well as broad implementation. Indeed, the development of robot seemed to have limitless potential. Serious futurologists predicted, for example, that in the 1980s the number of industrial robots will increase approximately by 35 per cent a year (Kahn 1982: 182). However, the growth was much more modest. The reason is that in the Western countries where large-scale industry has been excluded and the share of industry (and the number of workers) has been constantly reduced, the need for the substitution of workers has significantly decreased, and investments into the relevant research has also been reduced respectively.[1] Robotics continues to develop in such countries as Germany and Japan which in many respects have preserved their heavy industry unlike other developed countries.

In the 1990s robots continued to develop: there were improved the characteristics, software, and interface, the control became easier, *etc*. But the focus was on the development of information robots and not industrial ones (we have already spoken about the use of such robotic programs at the stock exchanges).

Apparently, the number of industrial robots will grow rather actively due to modernization of the developing countries' economies, but most probably, the industrial direction of robotics will not become breaking through at the initial stage of the final phase of the Cybernetic Revolution in the 2030s and still will gain pace a bit later.

According to the International Association of Robotics, in 2010 just over a million robots were involved in production in the world (only rather advanced machines which have at least three axes of mobility and possibility of free programming are taken into account). Every year the number of robots increases by 100,000 or even more 'individuals'. At the same time the trend of growing number of robots shifts to Asia (*e.g.*, in 2010 26,000 devices out of 120,000). First of all, robots are used here for work under sterile conditions (in electronic and in pharmaceutical industries), product assembling and packing (Smirnova 2011). Nevertheless, a considerable number of robots are still used in automobile factories where there are from 400 to 700 robots per 10,000 workers. In comparison, in electronic industry there are 100–200 robots for the same number of workers, and there are less than 50 robots in the food industry (*Ibid*.). Robots are actively employed in logistic centers and in some other areas. Fig. 7 shows the estimations of the industrial robots shipment.

[1] Process of deindustrialization is vividly described, for example, in Martin and Schumann 1997.

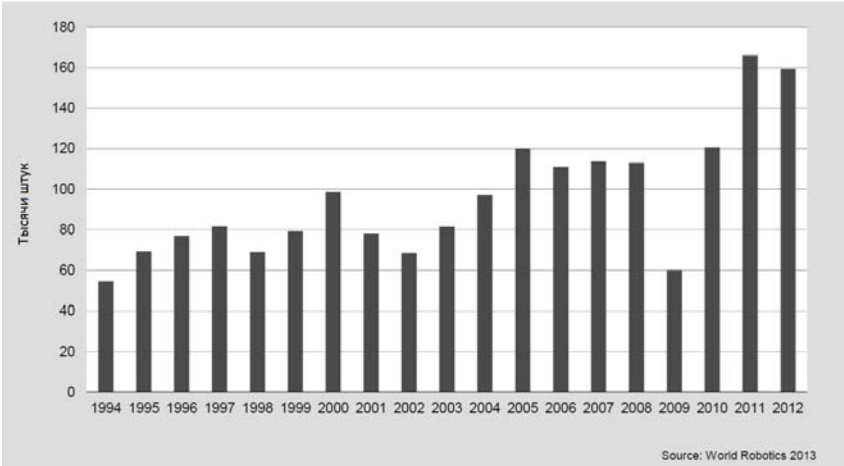

Fig. 7. Estimated worldwide annual shipments of industrial robots (1994–2012) (Tsirel 2014: 365)

Of course, robots have serious advantages over humans: they work much faster and besides, their work is more qualitative, their application also reduces the level of product failures which is extremely important when releasing expensive facilities. Nevertheless, industry has not immense market for implementing robots since there are a lot of countries with cheap and young labor force.

At present, along with first-generation robots (most numerous) various second-generation robots are developed. The active work is carried out on the design of the third-generation robots with high order of intelligence, adaptation and orientation.

One should also mention military robots or robot-like facilities since today the greatest part of robots is produced for defense needs – about 45 per cent. However, it is not surprising. From their very emergence the nuclear and space industries as well as aircraft industry where such mechanisms began to be used have been primarily connected with military tasks. All this has begun even before the Cybernetic Revolution. At first there were used ordinary technical innovations for production of military automatic machines (like magnetic torpedoes or torpedoes reacting to noise). Then devices with operating subsystems appeared. In fact, modern military rockets capable of bypassing obstacles and obtaining the target, as well as drone aircrafts, or even autonomous cars present very perfect systems, and it is rather difficult to find their precise differences from robots. But today the flying robots (also called pilotless planes, or drones) start to be actively used for peaceful purposes (a rather frequent trend of technological development) for checking the power lines or delivering first-aid equipment (they can also be used as messengers), in agricultural sector, for shooting and many other purposes when inexpensive and ongoing aerial support or supervision is necessary. So far the drones of this kind are controlled by a person on the ground.

Nevertheless, the experts believe that the following step in the drone technologies will be the development of vehicles operating autonomously and this will open numerous opportunities for their use in new fields.

At present, a number of military robots have been developed: spy rectangulars (including underwater vehicles), hospital attendants, mine-clearing robot and some others. However, the majority of military robots are remote-controlled by human operators, only very few models have an opportunity to fulfill some tasks autonomously. Thus, these (as well as other) self-regulating systems after all are still closer to the operated machines, yet, they advance towards self-regulation. At the same time it is obvious that the remote control even in technical terms does not work everywhere. For example, while controlling robotic missions in deep space there is a delay in receiving a signal at the expense of vast distance (about several minutes) that is unacceptable. Therefore, people need robots operated not directly by a person, but performing behaviors or tasks with a high degree of autonomy (see Yuschenko 2015).

1.2. Robotics in medicine and nursing

We have already spoken about a successful use of robots in medicine. In our opinion, this direction will unambiguously promote the start of the Cybernetic Revolution. Now surgical robots are most widespread. Robotic surgery started to develop in the 1980s. The surgical robot *Da Vinci* was one of the first robotic systems used to aid in surgical procedures. The working prototype was designed in the late 1980s within the framework of the contract with the US army. By 2015 more than 3,000 such machines have been constructed. Since 2000, about 1,370 American clinics ordered robots whose average price is about two million dollars for a system (Beck 2013).

Robotic surgery is a rapidly developing sector. In 2000, there were performed only 1,000 robotic surgeries world-wide. In 2011 their number already grew to 360,000, in 2012 – 450,000 (Pinkerton 2013). According to the research conducted by the Columbia University from 2007 to 2010, in the US clinics from 10 to 30 per cent of surgeries were robotically-assisted (Beck 2013).

Robotically-assisted surgery has many advantages. However, along with advantages robots (including the surgical ones), cause new problems and fears since the surgeries with involvement of these systems carry a significant risk. Thus, the doctors from Rush University Medical Center, the University of Illinois and the Massachusetts Institute of Technology provided the data which show a definite increase of the number of injuries and fatalities after the operations performed by the robots, from 13.3 cases per 100,000 surgical operations in 2004 to 50 cases in 2012. FDA registered a 34-percent increase of deaths after robotically-assisted surgeries in 2013, relative to the previous year (Pinkerton 2013). Thus, medicine and robotics are only at the beginning of the way; however, this direction looks very promising.

Currently, robots are actively involved in nursing-care and medical-care. In Japan they already test robots nurses. They help patients to get out of bed, render help to stroke victims in reasserting control over their limbs (Khel 2015). *GeckoSystems* produce robotic nurses and robotic attendants that with telepresence capabilities will permit doctors and nurses to monitor and examine patients remotely as well as change bed linen and give medicine to patients. In our opinion, it is one of the most challenging directions of using robots in the future. This market is estimated to be in the hundreds billions of dollars.

1.3. Forecasts of the development of robotics

So, we believe that in the next two–three decades robotics will develop more rapidly not in industry but in other spheres. First of all, in service industry. Why? First, today it involves the major part of the working population in the developed countries. For example, in the USA its current share has reached almost 80 per cent (World Bank 2016). The similar share of people employed in the sector is observed in other developed countries, and it is rapidly increasing in all states, including China, India, and the Third World countries in general, where the least intellectual and skilled work still exists. Most migrants move to Europe to work in this very sector, while the tension towards migrants is increasing. Thus, in economic terms this is the most promising sector for labor replacement since the industrial sector has already considerably exhausted its employment opportunities (besides, manufacturing will continue to grow in the developing countries with their abundant cheap labor). Here one can also mention robot cooks and robo-waiters. Secondly, more complicated jobs and service such as, for example drivers, consultants, especially health workers will be actively robotized due to the high price of their work. But probably robots will mostly substitute medical attendants and nursing staff (*e.g.*, medical assistants, laboratory assistants, nurses, surgical assistants).

Thirdly, robotics will continue to develop in the direction of robotic housing units (such as vacuum cleaners), including the Internet of Things (IoT) network. It will obviously provide a huge market and, moreover, give opportunities to connect robots to home computer or an operating center.

Forecasts of development of robotics in the final phase of the Cybernetic Revolution. The opportunities of using robots are undoubtedly vast. In particular, only these devices can help to solve the problem of care of growing numbers of elderly people and to some extent the associated problem of labor shortage. In general, there is no doubt that robots will play a significant role in the transition to self-regulating systems. Already today it is evident from the exploratory developments (though they are far from production). For example, the scientists from the Oslo University in Norway by means of 3D-printing has developed a category of self-learning and self-repairing robots which are able to take analyze the situation, and, using its integrated 3D-printer, produce a new part (Vogt 2014). This is a good example of integrated self-regulating systems. Another interesting example is the *Roboearth* project of the Internet for robots. Robots record all their operations into this remote database and can address it if the necessary operation is absent in their installed program. It is not just a self-regulating system, but to some extent it is the inchoate collective robotic intelligence (Waibel *et al.* 2011). The task of providing control over multi-robot system in the future is already set for robotics. A group of machines is able to fulfill qualitatively different tasks than one robot (Yuschenko 2015).

Also, it is not surprising that people have considerable interest in robots, as well as in any demonstrations of innovations in this sphere which draw attention and are always effective. But here one should point that although the ideas about 'smart' robots are very much important for us since they are a good example of the most important characteristic of the Cybernetic Revolution and its technologies (that is a transition to self-regulating systems), it is necessary to recognize that the forecasts about coming of such 'smart' facilities in the near future do not correspond to the real opportunities yet (just as well as the predictions of earlier researchers have not come true, see, *e.g.*, Moravec 1988).[2]

There are various assumptions of role of robotics in the near future. In 2007 Bill Gates (2007) considered that robotics was approximately in the same position as computers used to be in the 1970s when they founded the Microsoft Company together with Paul Allen and he apparently anticipated that in the 2030s robotics would become as important as ICT today. However, we consider that this prediction will not come true by the appointed time. Some firms work on these or those developments, but in general, unfortunately, there is not so much business interest in this direction yet, say, in comparison with bio- or even nanotechnologies though robotics has already a rather long history. Now the total volume of world production of robots is rather small, only several billion dollars. And even according to optimistic forecasts of the Japanese Association concerning robotics, by 2025 the turnover of the robotic branch will make only 50 billion dollars (Gates 2007), that is the volume absolutely insufficient for an economic takeover.

Therefore, there is no doubt that a bright future is awaiting for this direction. But most likely its rise will happen already during the Cybernetic Revolution on the basis of development of technologies of the future.

We assume that in the 2020s certain although not revolutionary achievements in this area will occur, in the 2030–2040s we will witness a much more significant rise in robotics, but an explosive development of robots will happen a bit later in the 2050–2060s. By this time it is also possible to expect the creation of really 'smart' robots.

[2] Some authors go very far and believe that in the twenty-first century robots will have all characteristics of human mental and physical abilities. In their opinion, the twenty-first century will become the century of the post-biological world when as a result of the natural selection robots will force a human out of the pedestal of evolution and will develop under the influence of the new post-biological evolution which can exceed the rates of the biological evolution millions of times (Wadhawan 2007). In our view this looks more like a scientific fiction than scientific forecasts.

In what particular direction will robotics start to develop quickly? We believe this will be the sphere of social nursing care for the infirm and with medical care, since let us emphasize again, this is one of the main directions that will allow at least a partial solution of the problems of care for elderly persons. Also, as it has already been mentioned, the development of robotics will be connected with service industry (there will appear robots-messengers, sellers, cashiers, consultants, inspectors, *etc.*), domestic life (cleaning, cooking, other domesticities, managing a household, *etc.*) or business.[3] There is great progress in robotized electric vehicles, which are self-driven and thus, can strongly reduce the number of drivers. As we have already spoken, programming will be also robotized, and there will be actively developed the robotic systems for the tasks that can be dangerous for humans (military, rescue and space activities, *etc.*). Hardly all of them will be anthropomorphous, most likely their design will be defined by functions. However, universal robots are also likely to emerge.

2. Universalization and 3D-Printers

Universalization as a characteristic feature of the Cybernetic Revolution. Universalization is one of the most important and even surprising characteristics and trends of the Cybernetic Revolution about which we have spoken insufficiently. This vector of technological changes will incorporate maximum possible operations from different technologies and will make them widely used, and for this purpose it will constantly combine various techniques and mechanisms existing and working independently. Technologies and devices become more and more functional, incorporating previous independent technologies as subsystems. At the same time this unification can be quite unexpected and can combine with a tendency towards miniaturization and individualization. The example of this kind is the computer currently integrating at least twenty functions (from a former typewriter to video camera, from a pencil to a secretary,

[3] There are also some exotic assumptions. For example, some researchers consider that one of the most perspective directions in development of robots is intimate services (we have already spoken about it in *Introduction*). By the way, robots already show considerable results and prospects in this sphere (Yeoman and Mars 2012). There are also apologists of this direction. In the book 'Love and Sex with Robots' David Levy (2008) assumes, for example, that by 2050 the relations between human and robot will be a universal and common phenomenon. However, it is quite possible (and it would be reasonable) that such production can be forbidden. Let us note that feminists have already begun such a campaign (see Griffin 2015).

from a tape recorder to the TV), and mobile phone. Even the Walkman has become multi-functional (though it will most likely disappear).

And what about a car? It includes so many functions now! It is a house, transport, mini-station and a concert hall simultaneously. On the basis of this universalization there developed do-it-yourselfer competences which we have already mentioned and which lead to disappearance of the number of professions. However, universalization is observed not only in electronic devices. We can trace it in the development of robotics where one of the main directions is to create multifunctional robots as well as mini-laboratories which also become more and more multifunctional.

In general the industrial production principle of the eighteenth-nineteenth centuries developed specialization; yet universal things were invented during this period as well (*e.g.*, electric motors). It should be mentioned that universalization did not clearly show up at the initial phase of the Cybernetic Revolution. On the contrary, specialization was seemingly increasing. However, the tendency came to the fore during the modernization phase of the Cybernetic Revolution and has been increasing ever since.

We believe that, first of all, this tendency has not come to maturity yet but it is likely to step forward in the final phase of the Cybernetic Revolution. Secondly, it actually leads to the emergence of complex self-regulating systems which, being multifunctional, will include a number of subsystems and technologies, yet their main element will be the system of management capable to self-regulation and self-management. Thirdly, this tendency will respectively reveal itself in various spheres. For example, we have already described health monitoring systems which will fulfil numerous functions. Besides, multifunctional robots are also most likely to appear. Fourthly, this tendency will promote the emergence of closely interconnected complex technologies.

One of the most recent trends in universalization are the 3D-printers which will probably start to compete with computers in terms of scale and scope of application. The opportunities provided by such printers are exclusively great: from building to cooking, from a house workshop to museums, from medicine to children's toys, from training models to design. These machines are actively used in such branches as aircraft construction and rocket engineering to produce individual details, for example, support stand for an aircraft engine (see, *e.g.*, Turichin 2015). And just because they are used in such spheres their development needs considerable investments.

In fact, these printers actually constitute a universal house workshop or a universal production, construction, or factory. And they will acquire new functions and incorporate new subsystems in the future.

These devices can exist in different sizes and use different materials (from refractory metals to paper with only exception for aluminum) and can manufacture most different objects. Three-dimensional or 3D-printer unlike the usual ones that print two-dimensional drawings, photos, *etc*. on paper gives a chance to synthesize three-dimensional information, that is to manufacture three-dimensional physical objects. With reference to 3D-printing we can also mention fusing of powder agglomeration of both polymeric elements and metal powders (we can observe here a link between printers and nanotechnologies).

Printing with a 3D-printer is a process of making of a real three dimensional solid object from a digital file, a template designed with 3D Computer Aided Design (CAD) software and saved in the STL format, and then the 3D-printer manufactures a real product by fusing layers upon layers of materials.

Fusing layers consists of a number of repeated cycles of creating three-dimensional models, applying a layer of materials on the working surface (elevator) of the printer, descending of the elevator platform by a distance equal to the thickness of a single layer and removal of waste from the surface of the working area. The cycles follow one by one continuously.

In industrial production (metallurgy and mechanical engineering) a detail is produced most often by subtraction that is a removal of the material (though casting and other methods are known), turning and drilling it, deleting superfluous material. The basis of 3D-printing is additivity, that is merging (fusing) of materials and creation of a certain construction (such technologies are called additive).[4] Due to a widespread use of 3D-printers long technological chains can be eliminated in some branches of production. It will be enough to have a sketch and to make (to 'print', 'fuse') a detail at home or in a 3D-printing center. It will also possible to organize a small single-piece production. Engineers could al-

[4] As well as of future assemblers of Drexler (1987, see also Drexler 1992, 2013).

so develop simple food 3D-printers which can print, for example, candies or pizza.

3. Cognitive Science and Cognitive Technologies

Cognitive sciences study the nature of mental and nervous processes which control movement and many other bodily processes. Actually it is a large complex of diverse areas connected with intellectual processes, consciousness, knowledge, memory, *etc*. We refer here to such fields as cognitive neurophysiology, cognitive neuroscience, *etc*. In the previous decades many discoveries have been made which explain some mechanisms and reactions of our brain and mentality, including the work of so-called neuromediators. A considerable number of neurostimulating pharmaceuticals of a new generation have been created which are actively used in medicine nowadays. In general there appeared a new direction in pharmacology – neuropharmacology.

The key technological achievement was the development of new brain-scanning technologies (including computed tomography, *etc*.) which for the first time allowed producing multiple images of the inside of the brain and receiving direct and not indirect data of its work. Nowadays many research organizations are involved in the studies and try to create a database of neuronal cells and their types (according to the latest data, there are 90 billion neurons in human brain). This will allow advance in the interpretation of the mechanism of visual system operating by means of development of a functional classification of different types of neurons in the brain.

Neural interfaces or brain-computer interfaces (which we spoke about in Chapter 3) can become one of the breaking through directions of cognitive science and the Cybernetic Revolution in general. Let us remind that neural interfaces are technologies connecting human nervous system with external devices (usually they implement the interaction between brain and computer systems). The basic achievement of cognitive sciences is an opportunity to control artificial organs via brain signals as healthy people do it. In 1924 the German scientist Hans Berger made the first recording of human brain activity by attaching electrodes to the head (Wolpaw J. and Wolpaw E. 2012). Later electrodes were embedded directly into human brain.[5]

[5] In 2010 there were about 35,000 people in the world with the electrode implanted into the brain (see Swaab 2014: 292–294).

After it was established that electric activity of neurons can help to operate robotic manipulators, the study of neural interfaces became even more active (Lebedev and Nicolelis 2006). Now they have managed to perform the transmission of neurons signals to devices and thus, to operate artificial limbs with a natural accuracy. We have already spoken about some of them earlier. Scientists are already adjusting the functioning of an artificial eye, ear, and heart by means of neural interfaces.

In the future neural interfaces can be applied not only in medicine, but also in daily pursuits, for example to control condition of a driver's or an operator's brain and in case of falling asleep to awake him automatically.

In general the achievements in cognitive science are already in use and their application will increase even more in the areas which move towards self-regulating systems – from medicine to robotics, from cybernetics to problems of artificial intelligence, and, of course, for the military purposes.

However, serious technical and social difficulties can hamper the development of this direction. Among obstacles one can mention, first, the immune rejection. Second, many nanostructures, for example, nanopipes, which had been predicted a bright future appeared very toxic for human body (Kotov *et al*. 2009). Third, the implantation of external devices leads to traumatizing of the whole organism despite all serious attempts to reduce this impact (Grill *et al*. 2009). Another problem is the different electric conductance of biological material and of a technical device, though there is certain progress in the solution of this problem (Abidian and Martin 2009). But even if we solve these problems we will still need some powerful software capable to handle brain signals. At the same time it is very important to find the means to provide feedback between a device and human brain, in other words, the brain should not only emit a signal, but also receive it from the device. After exceeding these constraints, the development of neural interfaces will promptly reach a new level. But to avoid the mistakes and problems like experienced ones from the spread of computer games (but with consequences of a much larger scale), it is necessary to preliminarily prevent data abuse and influence on mentality.

4. Transportation and the Cybernetic Revolution

In the middle or end of the final phase of the Cybernetic Revolution (between the 2040s and 2060s) one can expect a mass development of some new means of transport. In recent years the improvement of electric automobiles has proceeded rather quickly which is connected with the fight against emissions of greenhouse gases, high oil price, and government financial incentives. As a result the fleet of electric cars is quickly growing. By the end of 2015 there were more than one million electric automobiles. In a number of countries electric cars already have an essential share in sales of vehicles. For example, in Norway in 2013 it accounted for 6.1 per cent and more than 10 per cent in 2015. According to the forecasts of the International Energy Agency (which we consider too optimistic), by 2020 electric cars will amount to 2 per cent of the world fleet of motor vehicles which will make 20 million cars in numerical expression (see Sidorovich 2015).

Thus, the number of sold electric vehicles is growing quickly enough, in the near future they can amount to half a million a year or more. But one should point that more than 40 per cent of such cars are hybrid vehicles that combine a conventional internal combustion engine with an electric propulsion system (Statistics… 2015). It reminds a situation with steamships in the nineteenth century when many vessels had both the steam engine and the sails. Thus, the development of electric vehicles becomes already a significant sector in car industry. However, we should keep in mind that the importance of a sector may turn illusive since it can be much written and spoken about while the actual importance is rather modest with respect to the general scales of a branch. Besides, when new systems become widely available we face problems and drawbacks which are not so easy to eliminate. And this starts to hamper the initial fast development. Perhaps, the development of electric vehicles will be limited to a certain share of the automotive market (at least, in the next two decades).

Speaking about electric vehicles, one should mention the recent research (especially in Germany) in construction of highways, on whose separate lanes it would be possible to construct something like an electricity conductor by using special materials.[6] Then electric vehicles would recharge as needed (the so-called wireless charging technology). Certainly, such roads could change modern transportation system considerably.

[6] For example, there are projects of using solar batteries instead of pavement, or electricity will be charged from another source.

But taking into account the above-described 'meaning' of the Cybernetic Revolution (as a revolution of self-regulating systems), most likely, the breakthrough will happen in the direction of autonomous traffic and its management. That is transport vehicles and systems will become self-regulated and will incorporate the electric vehicle technologies. Even today there is some draft of realization of this opportunity. For example, Tesla Motors produces some models with autopilot; the German concern 'Mercedes-Benz' has presented the concept of the driverless car (della Cava 2015). And *Google* promises to create such a car by 2020 (see Google n.d.), but it already tests the Toyota self-driving car in California (and arranges joint projects with *Ford*). Just as in 1996 the computer defeated the world chess champion, recently self-driving car has beaten the race driver at speeds over 200 kilometers per hour. The record has been set up in Northern California – the car was faster only by 0.4 of a second (Prigg 2015). It is not clear how it will stimulate the development of driverless cars since chess competitions with computers have been little spread. However, engineers from Google especially emphasize that their new developments can make our usual daily trips much safer. Nevertheless, there are many obstacles, including legal and organizational (safety, fears and conservatism) on the way to the mass implementation of self-driving cars. It is impossible to overcome them quickly.

The spread of electric cars for the owners' private goals can be delayed since they have neither really important advances for mass users and impossible for conventional vehicles, nor can they evidently reduce the costs. Also since humans can drive cars themselves, quite few of them will be eager to pay for a robot. Thus, together with anxiety that such self-driving cars will leave millions of people without work in the near future there arise the obstacles for their mass distribution. In business terms the self-driving vehicles could dramatically change the freight transportation as well as taxi service. These self-driving cars can completely eliminate taxi drivers as a profession (Khel 2015) as well as truck drivers. But here there can emerge certain legal and social difficulties.

In any case the development of such self-regulating systems is an important forerunner of the forthcoming start of the final phase of the Cybernetic Revolution (in the 2030s). The self-driving electric vehicles with a new perfect accumulator[7] together with roads allowing free recharge can become a powerful source of technological development during the final phase of the Cybernetic Revolution and during the mature phase of the scientific-cybernetic production principle.

5. Other Technologies within the Cybernetic Revolution

The described processes must prove the idea that the final phase of the Cybernetic Revolution will be the era of a rapid development of self-regulating systems. Actually, already now we use a lot of systems of the kind, but do not take them as such. Others have not found a broad application yet like self-cleaning glasses, but soon enough they can become a part of our everyday practice. With the emergence of machines in the preceding centuries there appeared dozens of bright insights about their future application, and at the same time numerous ideas which failed to come true. And today it is difficult to define what will become a reality and what will not. But there is no doubt that the development proceeds towards the invention and wide distribution of self-regulating systems. We expect the development of such systems which will work almost independently and control important aspects of human life like today computer programs of spelling start checking your style or spelling. All this demands a deep understanding of the field of minimization as a solution to important present day and emerging problems. As already mentioned, the Cybernetic Revolution (like any production revolution) brings changes in all spheres of production and areas of life. However, these changes being part of a single large process will happen not simultaneously.

Now it makes sense to say a few words about changes in other spheres.

Specialization. Finally, there is no doubt, that the future technological changes will bring major and in many cases radical changes in the professional structure and competences of the population.

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[7] Li-Ion accumulators become cheaper quickly enough, there is progress concerning speed of recharge of accumulators. It may happen that use of graphene will become a breakthrough in production of accumulator equipment. The Spanish company *Graphenano* announced accumulators which are 77 per cent cheaper and easier than those used today and provide a driving distance of 1000 kilometers and at the same time are charged just in ten minutes (Sidorovich 2015). But one should keep in mind that such victorious reports may actually turn far less impressive or even just fancy talk.

The production revolution radically changes the specialist area of people, their professional skills (competencies) and creates a need for new professionals. The farmer and the craftsman replaced the competences of the hunter and gatherer during the Agrarian Revolution. With the emergence of metals specialists, stone working disappeared. But nevertheless, during the era of the Agrarian Revolution, changes were happening rather slowly.

Almost the whole period of the Industrial Revolution, since the sixteenth century and, at least, till the last third of the nineteenth century, passed under the banner of battles pitting the skilled craftsmen against the Leviathan of technological progress. This period is full of episodes of prohibitions on inventions, the acceptance by the representatives of factories of various constraining laws, and history of destroyers of machines, *etc*. Thus, the grounds for such bans and constraints were the most serious: product degeneration, falling of earnings, competition between the people having no necessary professional skills. However, as a result, machinery replaced manual operation, waves of technological innovations wiped out the groups of experts.

The initial (and even the intermediate) phase of the Cybernetic Revolution, especially with the spread of computers, has also led to changes in professional skills, including in the spheres of intellectual activity: typing, books publication, magazines and newspapers, translation, collection of information, library science and archiving, design, advertising, photo, cinematography, *etc*. There is not a long time from now when books in their present form will become a rarity. The emergence of 'do-it-yourself' technologies (a director, a publisher, an artist, a photographer, *etc*.) became an attribute of the time.

The further technological development will undermine the bases of many professions – from a doctor and teacher to a nurse and tax assessor. As we said above the robotic pilots can replace professional drivers and children and sick people could have their own electronic nurses.

On the whole, the general course of development should proceed towards the reduction of the workers in service industry sectors (both simple and more difficult types), but at the same time many new professions will be in demand. As we have already noted, the reduction of people involved in service industry will occur not least due to the development of robotics.

Power industry. During the previous production revolutions the energy source would also change. The Agrarian Revolution brought biological energy into use that was strength of animals; the Industrial one used at first water power, then it was replaced by steam power and then electricity and fuels.

An adequate energy source to start the Cybernetic Revolution, namely, electricity has already existed. The idea that a new leading energy source will become thermonuclear, hydrogen or some other new type of power has not been realized yet. There is a question: whether an adequate energy source for the final phase of the Cybernetic Revolution has to appear? The experience from the previous revolutions shows that it is not necessary at all. The transition to the irrigational intensive agriculture did not demand the obligatory use of animal draught power (for plowing) as well as the first sectors of the machine industry quite managed with the known water energy source. However later, in the end of the final phase of every production revolution and during the transition to mature stages of every production principle, new sources of energy appeared (so, the completion of the Agrarian Revolution in the rain fed zones was connected with agriculture with the use of bulls and oxen; and the completion of the Industrial Revolution – with the use of steam energy). It should be noted that in both cases it was not totally unknown energy. Steam energy was occasionally used since the seventeenth century.

Essentially new power source will not be required to start the final phase of the Cybernetic Revolution. Concerning the development of alternative (low carbon) power engineering will not play a decisive role here. However, a new energy source has to appear either during the final stage of the revolution, or a bit later. Also, most likely, it will not be absolutely new and not used previously. Most probably, thanks to technical innovations, it will become possible 'to tame' and to make sufficiently available this or that type of alternative energy (hydrogen, thermonuclear, solar; or it will be the invention of easily stored electric power which will also solve the problem with a power source for eco-friendly transport). At the mature stages of production principle changes in energy production also take place which create the base for a new production revolution (so during the maturity period of the craft-agrarian production principle the power of water acquired those properties, used for driving mechanisms, and during the maturity period of the trade-industrial production principle the electric power became such a source). But what energy will appear at the final stage of the scientific-cybernetic production principle is difficult to imagine so far.

Communications. The production revolution surely changes the ways of communication. At the beginning of the Industrial Revolution there was invented a new type of information technology which created one of the impulsive forces of communication. We mean the invention of printing. The role of the new types of communication and connection (TV and computer) became even more essential at the beginning of the Cybernetic Revolution. Thus, the initial phases of the production revolution can be caused by the emergence of new types of communication. However, it is not a prerequisite for the beginning of the final phase of a production revolution (though writing appeared on the eve of the final phase of the Agrarian Revolution, its role was not essential). New forms of communication could appear at the end of the final phase of a revolution or after it. For example, electric coupling (telegraph, telephone) was introduced after the termination of the Industrial Revolution.

Thus, in the next decades the emergence of essentially new types of communication is hardly possible. The development of communication has made great progress during the last decades and in general even surpassed the overall level of the development. Most likely, the revolutionary new types of mass communication can appear only toward the end of the twenty-first century. However the powerful progress in existing ICT is quite possible within the next three-four decades.

The development of communication via interfaces or via direct implantation of chips into human brain (thus, the communication will proceed from the source right to the brain) seems fantastic now; yet, if it succeeds it will hardly be widely implemented in the near decades (due to ethic, medical and legal restraints). Nevertheless, one can hardly ignore such opportunities and should think about restrictions beforehand since this possibility raise concerns.

On the whole we can suggest that new types of mass communications may emerge as a rather broadly implemented phenomenon not until the mid-twenty-first century but more probably by its end.