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Selected issues of artificial intelligence

2.1 Introduction

When considering the issues of artificial intelligence, we need to have a point of reference. This point of reference may be the definition of human intelligence. The literature contains many different definitions, but most of them come down to the conclusion that intelligence is the ability to adapt to new tasks and living conditions or a way in which humans process information and solve problems. Intelligence is also the ability to associate and to understand. It is influenced by both hereditary factors and by nurture. The most important processes and functions making up human intelligence are learning and using knowledge, ability to generalize, perception and cognitive abilities, e.g. ability to recognize a given object in any context. Moreover, we can list such elements as memorizing, setting and achieving objectives, ability to cooperate, formulation of conclusions, ability to analyze, creativity as well as conceptual and abstractive thinking. Intelligence is also related to such factors as self-consciousness, emotional and irrational states of human being.

The so-called man-made intelligent machines may be programmed to imitate only in a very limited scope, a few of above listed elements making up human intelligence. Thus, we have still a long way to go before we understand the functioning of the brain and are able to build its artificial counterpart. In this chapter, we shall briefly present the selected issues concerning artificial intelligence, beginning with the historical Turing test and the issue of the "Chinese room".

2.2 An outline of artificial intelligence history

Artificial intelligence (AI) is a term that stirs great interest as well as many controversies. The name was proposed for the first time by John McCarthy in 1956, when organizing a conference at the Dartmouth College on intelligent machines. The AI issues include, among others, the research for methods of solving problems. One of the examples is the research for chess algorithms. The logical reasoning is the second of many AI issues. It consists of building an algorithm imitating the way of inference occurring in the human brain. Another field of AI research is the processing of natu ral language, and in consequence, automatic translation of sentences from language to language, giving voice orders to machines and capturing information from voiced sentences and building knowledge bases based on this. AI researchers are faced with the challenge of creating software programs which learn by analogy and are able to perfect themselves. Predicting and forecasting of results and planning are also artificial intelligence domains. There is a large group of philosophers pondering over the problem of consciousness of an intelligent computer. The researchers also try to explore the processes of perception, i.e. vision, touch and hearing, and in consequence, to built electronic equivalents of these organs and apply them in robotics.

The literature presents different definitions of artificial intelligence:

a) Artificial intelligence is a science on machines performing tasks which require intelligence when performed by humans (M. Minsky).

b) Artificial intelligence is a domain of informatics concerning the methods and techniques of symbolic inference by a computer and symbolic representation of knowledge applied during such inference (E. Feigenbaum).

c) Artificial intelligence includes problem solving by methods modeled after natural activities and cognitive processes of humans using computer programs that simulate them (R. J. Schalkoff).

Even though AI is considered a domain of the informatics, it is a point of interest of researchers in other domains, like philosophers, psychologists, medical doctors and mathematicians. We may therefore firmly state that it is an interdisciplinary science, which aims to study human intelligence and implement it in machines. Knowing the definition of AI, we may ask the question: when is our program or machine intelligent? An attempt to answer this question was made in 1950 by the English mathematician Alan Turing. He is the creator of the so-called "Turing test" which is to decide whether the program is intelligent or not. This test consists of the idea that a man, using a keyboard and a computer screen, asks the same questions to the computer and to another person. If the interrogator is unable to differentiate the answers given by the computer from the answers given by a human, we can state that the computer (program) is intelligent. A known critic of the Turing idea was the American philosopher John Searle. He claimed that computers cannot be intelligent, because even though they are using symbols according to certain rules, they do not understand their meaning. To back up his thesis, the philosopher came up with the example known in the literature as the "Chinese Room". Let us assume that we have a closed room, in which there is a European who does not speak Chinese. He is given separate sheets of paper inscribed with Chinese symbols which tell a story. Our hero does not speak Chinese, but he notices a book on a shelf, written in a language he speaks and entitled *What to do when someone slips a paper with Chinese symbols under the door*. This book contains instructions how to make Chinese symbols correlated to the ones he received. To each question, the European prepares an answer according to the rules provided in the manual. Searle states that a man closed in the room in fact does not understand any of the information he is given, just like a computer executing a program. Therefore, there is an obvious difference between thinking and simulating thinking processes. According to Searle, even if we cannot distinguish between an answer given by a machine and a human, this does not mean that the machine is intelligent. Let us assume, however, that there is a machine which passed the Turing test. We can thus state that it is intelligent and able to think as such. In this case, Roger Penrose, the author of *The Emperor's New Mind*, wonders if it would be acceptable or rather reprehensible to use it for one's own purposes, not making note of its desires. Would selling of such machine, or cutting its power supply, which can be in such case considered as food, be ethical? In his book, Penrose describes one of the first AI devices. It was an electronic turtle built by Grey in the early 1950s. The device moved around the room using power from a battery. When the voltage dropped below a certain level, the turtle searched for the nearest socket and charged the batteries. Let us remark that such behavior is similar to the search and consumption of food by humans. Penrose goes further in his ideas and proposes to introduce a certain measure of "turtle's happiness" – the value from the interval, for instance -100 (the turtle is extremely unhappy) to $+100$ (extreme happiness). Let us also assume that our electronic pet may restore its power resources using solar energy. We can assume that the turtle is unhappy when it is in a dark place, where the sun does not reach (we can easily state that our artificial pet is hungry), and it really "enjoys" sunbathing. After such description of the device, few people could lock the turtle in a dark room, and still, it is just a machine, like a computer.

2.3 Expert systems

As one of many definitions states, the expert system is an "intelligent" computer program that applies knowledge and reasoning (inference) procedures in order to solve problems which require human experience (expert) acquired by many years of activity in a given domain. The general idea of expert systems consists in transposing the expert knowledge of a given domain to a knowledge base, designing an inference machine inferring on the basis of information possessed and adding a user interface used for communication.

The prototype of expert systems was the DENDRAL program, developed in the early 1960s at the Stanford University. Its task was to compute all possible configurations of a given set of atoms. The integral part of the program was a knowledge base containing chemistry laws and rules, which had been developed in chemical labs for decades. DENDRAL proved to be very helpful in solving issues for which analytical methods weren't developed.

At the same Stanford University in the 1970s, two other expert systems were created, which became a historical benchmark solutions in this domain. The PROSPECTOR system was designed to support geologists in defining the type of rock based on contents of different minerals. It facilitated the research for mineral deposits and estimation of deposit volume. PROSPECTOR was a conversation system using the rules obtained from specialists. Models of particular types of deposits contained from several dozens to several hundreds of rules constituting the knowledge base, which was separated from the inference mechanism. The use of PROSPECTOR proved to be a spectacular success as rich deposits of molybdenum have been discovered in Washington state (USA). The MYCIN system was designed to diagnose contagious diseases. The system was fed with data concerning the patient and the results of lab tests. The result of its operation was the diagnosis and recommendations for treatment in certain cases of blood infections. This system supported the decision-making process in case of incomplete data. In case of doubts the system provided the degree of certainty of its diagnosis and alternative solutions (diagnoses). On the basis of MYCIN system, the NEOMYCIN system was created and was used for training doctors.

It is worth to mention one of the largest projects in the history of artificial intelligence, known under the acronym CYC (the name is a fragment of the word encyclopedia) and developed in the USA. This system contained millions of rules (it was planned to have ultimately 100 million rules), which was supposed to give exceptional "intellectual" possibilities to a computer with appropriate software.

As has been mentioned before, the basic elements of an expert system are: a knowledge base, an inference machine and a user's interface. The knowledge base is made of a set of facts and rules. The rules are logical sentences which define some implications and lead to creation of new facts, which as a result allow to solve a given problem. The inference machine is a module which uses the knowledge base. This module may use different inference methods to solve the problem. The so-called shell expert systems are gaining on popularity – these are computer programs with a designed inference machine and an empty knowledge base. These programs are all equipped with special editor programs allowing to enter rules concerning a given problem the user wishes to solve. The issues of constructing expert systems are part of the so-called knowledge engineering. The scope of interest of specialists operating in the domain of knowledge engineering covers such issues as knowledge acquisition, its structuralization and processing as well as designing and selection of appropriate inference methods (inference machine) and designing appropriate interfaces between the computer and its user.

2.4 Robotics

The term "robot" appeared for the first time in 1920 in a play entitled "R.U.R" by the Czech author, Karel Čapek. The play presented a vision of inappropriate use of technology by humans. The story is developed around a factory which produces robots – slaves which are to replace humans in heavy tasks and difficult work. The industry producing robots is being developed and the machines are modernized and equipped with increasingly growing intelligence. A large demand allows to increase the number of robots built. Finally, they were used for military purposes, as soldiers. A time has come when the robots outnumbered their creators – humans. The play ends with a revolt of robots and with the end of human kind.

The dynamic development of robots was initiated by research conducted in the USA. In 1950s, robots developed to work in factories were created – among others, they assembled cars at a General Motors factory. Works were undertaken to build manipulating machines for nuclear industry and oceanographic exploration. Currently, the robots are small wonders of electronic engineering and their prices often exceed the prices of luxury cars. They are basically used everywhere. They perform all kinds of works, from insignificant and trivial, like bringing slippers or serving coffee, through works in difficult conditions in heavy industry, considered difficult and hard for people, to complicated surgical operations. In 2002, a robot steered by professor Louis Kavoussi from the distance of one thousand kilometers performed a surgical operation. The role of doctors supervising the work of the machine was limited to anesthetizing the patient. This way, the patient does not have to wait for the doctor to arrive, which significantly lowers the costs and the duration of the procedure. The da Vinci robot made by Intuitive Surgical imitates the movements of the surgeon's hands during operation, and at the same time eliminates the shaking. Moreover, it displays a large, magnified picture of the patient's heart. It facilitates the procedure, as the surgeon can precisely see the operated organ. The precision of robots causes a significant reduction of damages to the patient's tissues. Due to that, the patient may recover faster. Robots often replace people when difficult jobs e.g. disarming bombs must be performed.

For the last few years, the Japanese company Honda has presented subsequent versions of the ASIMO robot. Its creators claim that the robot speaks two languages – English and Japanese, and is able to hold a conversation. It smoothly moves up and down the stairs and avoids different obstacles. AIBO is another interesting robot. It was given the form of a metallic silver dog, which can play with a ball and pee, for instance. However, it has problems with avoiding obstacles and cannot climb or give a paw. One of the versions was able to recognize 75 voice commands. To learn the mode of operation of this toy, the user must go through a 150 – page manual.

The researchers ask themselves how intelligent a robot should be and what its intelligence should consist in. Two main approaches are emerging, referred to as the weak and the strong artificial intelligence hypothesis. *The weak hypothesis* of artificial intelligence assumes that an intelligent machine is able to simulate the human cognitive process, but it cannot experience any mental states by itself. It is possible that such machine succeeds in the Turing test. *The strong hypothesis* of artificial intelligence leads to the construction of machines that are able to reach cognitive mental states. This approach allows to build a machine which is conscious of its own existence, with real emotions and consciousness. Many research centers lead research on human brain and the entire nervous system of the human being. The understanding of rules functioning in nature will allow to build a "thinking robot". One of the examples is the "Dynamic Brain" robot, the creators of which (neurophysicists Stefan Schaal and Mitsuo Kawato) searched for the rules of learning and self-organization which enable a system to develop its own intelligence. This robot, by watching a film with a woman performing a Japanese folk dance, learned to dance. The project authors use the robot for research on the human brain functioning and interactions occurring between the brain and the human body.

The robot called Cog, created by Rodney Brooks, was supposed to have the intelligence of a six-year old child. The objective of this project was to study the issue of robot development, its physical personification and combination of sensory and motorical skills as well as social interactions. Cog imitated human reactions, was able to focus its vision on objects and extend its arms toward them. When moving, it corrected its actions. Its capabilities were developed towards the ability to recognize objects and living organisms. The opinion that a robot's skills may be very extensive was expressed by Cynthia Breazeal. She built the "Kismet" robot able to learn many behaviors. It was supposed to be able to communicate with people, understand their emotions and express its own emotions using "facial" expressions. The perspectives of robotics achieve unprecedented perspectives. For example, in the USA at the end of the 20th century, an extensive program of research in the area of molecular machines was initiated. One of the basic objectives of nanotechnology development are miniature robots – nanorobots, which may be helpful in supporting the immunological system, detecting bacteria, viruses and cancer cells.

2.5 Processing of speech and natural language

The obvious manner of communication between people is speech. Communicating with the computer or with other devices using spoken language may be a significant facilitation in the life of orally and aurally challenged or physically disabled people. The author of the "Chinese Room" concept, John Searle, answered the question concerning the most important achievements of AI: "I do not know the technological progresses in this domain well enough to give a specific answer. However, I have always been fascinated by achievements in the domain of natural language processing. I believe these works are worth real recognition". Research in the scope of speech and natural language processing covers the following issues:

a) speech synthesis,

b) automatic speech recognition,

c) natural language recognition,

d) automatic translation.

Speech synthesis may be considered equal to the attempt made by a computer to read a book. Speech synthesis has many applications, e.g. to learn foreign languages or to read information for blind people. The study of speech is not an easy task. This results from the fact that a person, when uttering words, intones them appropriately. In order to utter a given sentence, we have to understand its sense, and the computer is not conscious in this matter (as well as in all other issues). An interesting idea was the application by T.V. Raman, manager of IT specialist teams at Adobe, of different typefaces depending on how the computer should read a given text. For example, sentences written in italics are read more loudly. The program on which he worked is called ASTER (Audio System for Technical Readings). The application of ASTER for its author is basically a must, as he lost sight at the age of 14, but it is also used by his colleagues at Adobe, for whom it is a significant facilitation of their daily work. At first, creators of systems imitating human speech attempted to create devices modeled after the human speech organ. Unfortunately, the effects of operation of machines and programs based on formants were not satisfying and significantly differed from human speech. Therefore, such approach was abandoned, and the researchers started to use in algorithms pre-recorded fragments of speech, which were to be put together in an appropriate way. It appeared that it was a very good idea. This idea was applied later in various modifications and improvements of this method.

Another issue studied by AI researchers is automatic speech recognition. The development of this research will enable the communication with the computer, e.g. dictating texts, giving oral commands or voice user recognition (authorization). As we have already mentioned, people pronounce words in different manners (intonation, rate of speech, etc.), often at variance with the rules of grammar. The example of an operational system is the "Dragon Dictate". In the first phase of experiments, this program required a few hours of "adjustment" to the manner of speaking of the person who would dictate the text. Currently, this system is commercialized, just like its competitor, program called Angora. These systems utilize databases, in which words are placed together with their sound or phonemic representation. Based on comparisons, the system recognizes the word. The example application is, for instance, voice selection in cell phones, where each name has its voice label recorded by the user.

Another AI issue is natural language recognition. The problem comes down to retrieving essential data from sentences recorded in the form of text. The researchers create systems to capture knowledge from sentences and the computer should make the division of the sentence into parts of speech. This way, it is able to extract from the contents the objects (nouns), their qualities (adjectives) and relations between them. Earlier, the systems were prepared to work for specific branches of science and they included data from a given branch in a knowledge base. The example may be the Lunar system which answered the questions concerning rock samples brought from the moon.

The last AI issue is automatic translation. It consists in translating texts between various languages. Systems of this type are used by the European Union institutions. It should be noted that the problem may consist in different meaning of words depending on the context. Forty years ago in the USA, a report was formulated, which contained the statement: "No automatic translation of a general scientific text has ever succeeded, and there are no prospects for a quick progress in this scope." Currently, there are translation programs operating on PCs available on the market. However, there are still problems with translation of texts containing sentences from a narrow domain, e.g. different technical documents. The Transcend software may be used as an example. It operates on personal computers and is able to process several thousand words per minute. There are also systems which are able to translate spoken utterances (e.g. over the phone) in real time. Very fast, usually multiprocessor computers are used for this purpose.

2.6 Heuristics and research strategies

The word "heuristics" comes from the Greek words *heurisco*, which means to discover, to find. The easiest description of heuristics may be "creative solution of problems", both logical and mathematical, by way of experiment, trial-and-error method or by using analogies. Heuristic methods are applicable everywhere, where a solution of a problem requires large volumes of computation. Thanks to heuristics, we may eliminate some areas of the space searched. As a result, we may decrease computation costs, and at the same time speed up the discovery of solution. The literature does not provide any formal proofs for the correctness of operation of heuristic algorithms, but their efficiency is confirmed by simulations made. They are widely applied, among others, in expert systems, decision support systems and operation research. The defeat of the chess world champion by a computer was possible also thanks to heuristic techniques, which allowed to exclude variants not portending success. To understand what heuristics are, let us present a well known example in literature [70]. Let us assume that someone dropped a contact lens. Here are some possibilities for search:

1. Blind search – bending down and feeling around for the lens. Such search does not guarantee a positive result.

2. Methodical search – it consists in expanding the space of research methodically and in an organized way. It always guarantees the success, but is very time-consuming.

3. Analytical search – requires the solution of a mathematical equation concerning the fall of the contact lens, taking into consideration the air resistance, wind power, gravitation. It also guarantees the success, but is impractical.

4. Lazy search – consists in finding the nearest optician and purchasing a new lens.

5. Heuristic search – we define the approximate direction of the fall and we presume how far the lens could fall and then we search the selected area. It is the most natural behavior and we most often unconsciously select this method of proceeding.

In the example above, blind and heuristic search were referred to. We talk about blind search when we do not use information on the domain of the problem to be solved. In heuristic search, we use additional information on the space of states and we also are able to estimate the progress improving the efficiency of operation. The process of heuristic search is best presented in the form of tree or graph. In the literature, different strategies of graph search and defining the heuristic solution are considered.

Returning to chess: we may state that as soon as after just a few moves, there is such an unimaginable number of combinations that it is difficult to analyze them even using the best existing computer. Therefore, the current computer programs apply the techniques of artificial intelligence and in particular specially selected and well-developed heuristic methods. Thanks to it, chess computers are able to play a fair match with the best chess players of the world. Let us remind that in 1996, Garry Kasparov won by 4:2 the match with the first model of the Deep Blue computer. However, the following year he lost the match by 2.5:3.5 with the second model of this computer called Deep Blue II. Deep Blue II was a super-machine manufactured by IBM, with 32 nodes, and each of them was equipped with a board containing eight specialized chess processors. Therefore, each current move was analyzed simultaneously by 256 processors. Such processor capacity allowed to analyze 200 million positions on the board in one second. Additionally, this computer had a database containing all the openings from the last 100 years and a database with over a billion possible game ends. So, to win with a human being, incredible processing capacity was used. Next time, Kasparov met with a machine in 2003. This time, his opponent was a computer program called Deep Junior 7. It was written by two Israeli developers – Amir Ban and Shay Bushinsky. This program operated on a computer with 8 processors, much slower than Deep Blue. Its distinctive feature was a deeper knowledge of chess. The tournament, which lasted from January 26 to February 7 in New York, ended with a 3:3 draw. Deep Junior 7 analyzed 3 to 7 million positions of the chess board per second, and Garry Kasparov – a maximum of only 3. Only this comparison may be enough to convince that the computers are very far from the human way of thinking. However, humans are hampered by the fact that they tire quickly and are moreover led by emotions, which also impacts the game result.

2.7 Cognitivistics

Cognitivistics as a science exists for several decades now. In 1976, the quarterly magazine *Cognitive Science* was issued for the first time; it published the results of scientific research in that domain, and in 1979 the Cognitive Science Society, seated at the University of Michigan, was created. From that year, also scientific conferences have been organized, attracting researchers from all over the world. Apart from the name cognitivistics, we can come across other names like cognitive sciences or cognition science. Cognitivistics is the discipline of science which tries to understand the nature of the mind and which studies the phenomena concerning the mind. An essential issue of the cognitive sciences is the analysis of our method of perceiving the world and an attempt to understand what is going on in our minds when we perform basic mental operations. To this aim, studies on the functioning of the brain and models of its operation are used. The science uses scientific achievements of neurobiology and psychology. Cognitivistics is interdisciplinary by nature, therefore this science uses the methods and studies of other sciences, such as anthropology, psychophysics, artificial life, logic, linguistics, neurophysiology, philosophy, artificial intelligence and many other branches of science. We should firmly state that the interdisciplinarity is absolutely necessary for the development of cognitivistics. This science studies an extremely difficult research problem, which is the description of the functioning of the mind. It is obvious that the theories and methods developed only within one branch of science cannot lead to the solution of this problem. That is why any effective results may be obtained only by large research teams consisting of representatives of all the abovementioned disciplines. We should add that cognitivistics has a whole range of practical applications. For example, such domains as neurobiology, psychology and linguistics require the cooperation of appropriate specialists to develop methods of treating speech disorders after a cerebral hemorrhage. Another area of application are the cognitive models used to create computer software interfaces. One of the concepts provides for a possibility to create the image of associations we have in our minds on a computer screen.

A large challenge for the cognitive sciences is the creation of adequate brain models. Current models in the form of artificial neural networks are insufficient and have few things in common with their real equivalent. Moreover, the researchers in the area of cognitivistics will undoubtedly dwell for a long time on the issue of the so-called weak and strong artificial intelligence, which was already discussed in Subchapter 2.4.

2.8 Intelligence of ants

Ants are insects the survival of which depends mainly on cooperation. Many times, we have watched the anthill and dozens of ants wandering chaotically in search of food. When one of them managed to find its source, then other ants followed it shortly. The researchers were interested in the way ants find their way from the anthill to food. It turns out that ants usually choose the shortest route possible. The anthill was separated from the source of food and only two sticks were left – longer and shorter – as the only path. After a few minutes, it appeared that the ants started to return from the food source by the shorter way. The second experiment was made, during which only the longer stick was left. Of course, the ants immediately found their way, but when the shorter stick was added, they continued to walk the old way. After a closer study of their behavior, the researchers found out that an ant, during its march, leaves a trail behind it, in the form of a substance called pheromone, and thus creating a scent path. Its companion, when smelling such path, follows it, also leaving a trail. The next ant selects the path depending on the concentration of the pheromone in any given place. They then head where the largest number of their companions have passed. But what will happen when the source of food runs out? It appears that there is a solution to that as well. The pheromone volatilizes after some time, loosing its intensity. A path less frequented will just vanish after some time. Another behavior of ants attracted special interest from the researchers. Ants remove the bodies of their dead companions by piling them in stacks. It turns out that a small heap of bodies is enough for a "cemetery" to come into existence at this very spot. Also here, ants apply a very simple principle – they transport dead bodies to the place where there are already other bodies. This ant clustering may also be used in practice, for example in banking. The credit decision consists in reviewing customer details and defining whether he/she is creditworthy or not. Such factors as age, work, marital status, use of other bank services, etc. are taken into consideration. By imitating the behavior of ants, it is possible to create clusters of people with similar features. It turns out that dishonest customers are usually characterized by similar features. Verifying the customer will therefore consist in matching his/her data to an appropriate cluster and checking whether the customers classified therein are creditworthy. There are similar systems operating by this principle, but the advantage of the method described above is that the clusters are not defined top-down – they are created naturally.

Based on these observations, a certain type of algorithms has been created, called *ants algorithms*. The work of "artificial ants" applied in these algorithms differs a little from their living counterparts, and namely:

a) they live in an artificial discrete world, therefore they move on a completely different ground, for example between the graph vertexes;

b) their pheromone trail vanishes faster than in the real world;

c) the amount of pheromone secreted by an artificial ant depends on the quality of solution it obtained;

d) in most cases, the pheromone trail is updated only after the solution is generated.

These algorithms are used to solve difficult problems of combinatorial optimization, such as *the Traveling Salesman Problem*, for instance. The Traveling Salesman Problem is that he is supposed to visit a given number of cities by the shortest possible way. The cities are variously distant from one another, he cannot miss any of them and he cannot visit the same city twice. The task seems easy to solve using the algorithm checking all the variants. However, when we have just a dozen of cities, the number of possible ways increases to billions. Nevertheless, this may be perfectly solved using ants algorithms, i.e. using the work of "artificial ants".

Ants algorithms can be also used to solve discrete optimization problems, for instance to define vehicle routes, sequence sorting or defining routes in computer networks. They are applied in practice in telecommunications networks of France Telecom and British Telecommunications. Telephone exchanges are sometimes interconnected by low-capacity connections. When the load of the network increases, for example during TV phone contests, these connections get clogged. The solution is to use virtual agents, the work of which is based on ants behavior, thanks to which subsequent telephone exchanges may increase the capacity by avoiding overloaded segments of the network.

2.9 Artificial life

Artificial life is a relatively new branch of science. It was born in 1987 at the conference in Santa Fe in New Mexico (USA), where the term *Artificial Life* appeared for the first time. Christopher Langton, organizer of the said conference, defined artificial life as follows: "Artificial life is a domain of science dedicated to understanding life by attempting to extract the basic rules of dynamics which influence the biological phenomena. These phenomena are reproduced using different media – for example in computers – to be able to fully use new experimenting methods". It is a discipline of science which uses, among others, the achievements of biology, chemistry, physics, psychology, robotics and computer sciences. It deals with the simulation of life as we know it, but there are also works that study behaviors of organisms built on completely other basis than earthly creatures. However, the basis of this discipline of science is the definition of life. Unfortunately, researchers are not unanimous in this issue. The main reason why it is difficult to define this term is certainly the fact that we are dealing only with the forms of life present on Earth. The earliest, simple and well known example of artificial life is the *Game of Life*. The game was created in 1968 by the mathematician John Conway, who based its operation on cellular automatons. In this case, the environment is a two-dimensional grid of cells, the state of which may be described as full – representing a live cell, or empty – lack of live cell. The rules are very simple. A cell dies of loneliness or overcrowding, and a new one appears when it has exactly three neighbors. During the simulation, when visualizing it, we could observe quick, dynamic growth of cells, creating wonderful patterns, and just after it, declines of entire colonies, for instance. Initial, even only slightly differing settings of cells lead during simulation to very complicated and interesting patterns.

Another very interesting example of artificial life are *biomorphs*. Their creator is Richard Dawkins, a British zoologist. They were created in order to study the evolution of forms. Biomorphs are graphic shapes recorded in genotypes, the appearance of which reminds of living organisms. Dawkins applied simple genetic operations to obtain new shapes in subsequent generations. By starting the evolution from simple figures similar to trees, we can obtain shapes of insects and bugs. The simulation of growth of organisms was conducted using a formal description of development of so-called *L-systems*, proposed in 1968 by Aristid Lindenmayer. They were later used to describe and model plants growth. The effects were similar to the operation of fractals.

Tierra system is a virtual world created by the biologist Tom Ray. The environment is in this case a virtual computer, where programs-individuals live. These programs are written in a special, simple language reminding of an assembler. The evolution of individuals progresses using mutations, or a random exchange of one instruction, or recombination consisting in replacing a part of the code. The individuals compete with each other for resources, or the virtual machine memory, and for the time of processor use. Thus, they try to take as much space as possible, and use as much of their instructions as possible as compared to other individuals.

Framstick system is currently one of the most advanced artificial life projects. It has been conducted since 1997 by two Poles: Maciej Komosiński and Szymon Ulatowski. The simulations are performed in a virtual, three-dimensional world, where there are both land and water environment. The organisms (framsticks) are build of sticks, which additionally can play the role of receptors (having the sense of touch, balance or smell) or the function of the movement organs (using appropriate muscles). The organs of movement are steered with the help of the nervous system based on a neural network. Framsticks compete with each other for existence in the environment by fighting with each other and searching for food. Each of the individuals is described with a genotype, which is a special code describing its construction. Three types of chromosome notation are available: the first one – the simplest and describing directly the construction of framstick, the second has the form of a recurring notation, and the third one consists in notating the information on particular cell. The evaluation of adaptation is performed in the same environment and may take different forms. An individual may be assessed depending on its movement, size or resistance. The simulation may also take different forms, e.g. searching for the highest individual. Next generations of individuals are created by way of evolution, which consists of selection, mutation and crossover of genes. The evolution relates both to the external form of organism and the nervous system.

2.10 Bots

A bot is an automaton, a software tool, a program used most often to search and retrieve data. Intelligent bots can additionally make decisions based on knowledge acquired earlier. Currently, we may differentiate several kinds of bots, which due to their capabilities have been divided to:

1) chatterbots – these are automata for chats. They imitate natural language conversation, acquire information from the interlocutor;

2) searchbots – they maintain automatically databases, are used to search, index and collect data;

3) shoppingbots – these are automata help us when shopping over the Internet. They browse sites in search of given products, creating a report on price differences;

4) databots – automata to search data, solve problems; their construction is based on neural networks;

5) updatebots – are used to update data possessed by the user. They inform on changes in network resources;

6) infobots – programs automatically providing answers using e-mail. They are used to provide technical support and marketing information.

Among the bots, the greatest popularity and interest is shared by chatterbots, especially as a tool to analyze customer expectations in marketing. They are most often placed on web sites, used to promote products and help the navigation. For the companies that use them, they are a source of knowledge on customers, as during a conversation a lot of information can be obtained. We should watch whom we are chatting to, using the Internet, as it may be a chatterbot? Internet users find it difficult to identify the interlocutor, all the more as they do not expect to be chatting with an automaton. They are very surprised when they discover that it was only a computer program on the other side.

The first *chatterbots* appeared around 1966 as attempts to execute the CMC (*Computer Mediated Communication*) project, the objective of which was to initiate the human-computer communication. In 1968 Eliza was created – a program made only of 240 lines of code, simulating a conversation with a psychotherapeutist. The program was able to understand the structure of a sentence by analyzing the key words and formulate questions on this basis.

For many years, the developers specializing in writing intelligent chatting programs have been competing in a special contest. Several times in a row, the best developer was Richard Wallace, who created the bot called ALICE (*Artificial Linguistic Internet Computer Entity*). It is one of the best existing bots (www.alicebot.org). It owes its advantages to the users, with whom it talked, enriching its knowledge base. It is worth noting that even such a good program did not pass the Turing test as part of the mentioned competition. Different versions of ALICE program have commercial applications, e.g. to promote new products.

2.11 Perspectives of artificial intelligence development

For years, the researchers have been arguing on the perspectives of artificial intelligence development. Let us quote some statements of renown specialists in this domain.

Roger Penrose (professor of mathematics at Oxford University) in his book *The Emperor's New Mind* expresses the opinion that mind processes of humans differ fundamentally from computer operations. No machine working on the basis of calculations will be able to think and understand like we do. Processes in our brain are "non-computational". Moreover, Roger Penrose believes that human brain is completely explainable in the categories of physical world, but only the existing physical theories are incomplete to explain how our thinking processes proceed. Dr. Ray Kurzweil, studying, among others, the commercial application of artificial intelligence, claims that the disappearance of differences between machine and human is only a matter of time, as human brain in the last few centuries almost did not develop. Meanwhile, in the last twenty years, its electronic counterparts are developing at an incredible pace, and this trend is certainly going to hold in the years to come. Hans Moravec (director of the mobile robots laboratory at Carnegie Mellon University) thinks that "man is a complicated machine... and nothing more". He gained reputation with a daring statement that "in the future, human nervous system may be replaced by a more complex, artificial equivalent". He claims that sooner or later, Earth will be populated by products of our technology, more perfect and better managing the difficulties of life than sensitive and vulnerable representatives of *the homo sapiens* species. Kevin Warwick (professor of cybernetics at Reading University) claims that after we switch on the first powerful machine with intelligence comparable to human intelligence, most probably we will not be able to ever switch it off. We will set up a time bomb, ticking over human species, and we will be unable to disarm it. There will be no way to stop the march of the machines.

As we can see, research on artificial intelligence fascinates the scientists, but also stirs great controversies. When summing up the opinions and experiences of different researchers and eliminating extreme views, we may claim the following:

1) No machine made by humans so far ever managed to go outside of the set of rules programmed by man.

2) Artificial intelligent systems will not simulate exactly the functioning of human brain. It relates to hardware limitations and a large complexity of the brain.

3) Machines may pass the Turing test in a limited thematic scope (sports, chess, advisory system in economy or medicine).

4) In the future, it may seem to us that machines show signs of consciousness. However, machines will not be conscious in the philosophical sense.

5) In the perspective of several decades, intelligent machines will be our partners at work and home.

6) Computers will design next generations of computers and robots and will play a significant (dominant?) part in development of intelligence of inhabitants of Earth.

2.12 Notes

In this chapter, we have discussed, in a way accessible to the Reader, some selected issues of artificial intelligence. Detailed information can be found in many literature items on this subject. The most important directions of research in the scope of human intelligence were discussed in the monograph [143]. Historic and philosophic threads of discussion in the domain of artificial intelligence are contained in monographs [105,168]. Chess games between the machine and man have been discussed in articles [81, 124, 229]. The issues of expert systems are presented in monographs [5, 25, 89, 141, 146, 170, 179, 268]. The issues of robot construction and their applications discussed by authors of book [61] and [135]. The issues of speech and natural language processing have been discussed in works [45, 154, 228]. The idea of heuristic search and algorithms applied have been explained in works [62, 70]. The history and development of cognitivistics is presented in article [46]. Ants behavior and ants algorithms have been explained in study [14]. Different models of artificial life have been discussed in articles [114, 169]. Work [75] presents the applications of artificial intelligence in electrical power engineering, work [170] – in technical diagnostics, work [268] – in economics and management. Following monographs on artificial intelligence, classics of the world literature, are well worth recommending [129, 147, 184]. In monograph [245], the authors presented a very interesting approach to the issue of image recognition using artificial intelligence methods, and in particular they introduced the term of so-called "automatic understanding of images". In this chapter, we discussed only a few threads of the artificial intelligence issue. We refer the Reader interested for instance in multiagent intelligent systems to monographs [52, 109, 127, 255]. On the other hand, monograph [27] is a comprehensive study of learning systems and presents classic methods of artificial intelligence, like, for instance, the issue of decision trees induction and rules inductions as well as probabilistic methods and induction logical programming.