# THE GENESIS AND DEVELOPMENT OF ARTIFICIAL INTELLIGENCE IN RUSSIA AND ABROAD AS AN INDEPENDENT SCIENTIFIC AND INTELLECTUAL BRANCH: CONCEPTUAL APPARATUS

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***Abstract:*** *in the scientific article, we examined in detail the genesis and formation of various types of artificial intelligence, which play a vital role in the protection of data, including personal data. The article also explains what artificial intelligence is and its types, how and where neural networks are used for security purposes, and also describes the advantages and limitations of using neural networks in cybersecurity. The scientific work also examined the trends that artificial intelligence will soon form in the field of cybersecurity. As AI technology advances, it will become increasingly important for organizations to leverage AI in cybersecurity. Today, Artificial Intelligence can help improve your security and detect attacks faster than ever before, making it an invaluable tool in protecting your data from attackers. The integration of artificial intelligence into cybersecurity is no longer a distant pipe dream, but a reality that shapes and strengthens defenses against the ever-growing and sophisticated cyber threats looming over the digital world.*
***Keywords:*** *artificial Intelligence (AI), expert system, cybersecurity, neural network, cyber attacks, phishing, hackers, safety, digital environment, internet, global network - internet.*

# ГЕНЕЗИС И РАЗВИТЕЕ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В РОССИИ И ЗАРУБЕЖНОМ КАК САМОСТОЯТЕЛЬНОЙ НАУЧНО-ИНТЕЛЛЕКТУАЛЬНОЙ ОТРАСЛИ: ПОНЯТИЙНЫЙ АППАРАТ

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***Аннотация:*** *в научной статье, мы подробно рассмотрели генезисе и становление различных видов искусственного интеллекта, которые играют важнейшую роль в защите данных, в том числе и персональных. Также в статье объясняется, что такое искусственный интеллект и его виды, как и где нейронные сети используются в целях безопасности, а также описываются преимущества и ограничения использования нейронных сетей в кибербезопасности. Также в научном труде рассмотрели тенденции, которые искусственный интеллект вскоре сформирует в области кибербезопасности. По мере развития технологий искусственного интеллекта организациям будет становиться все более важным использовать искусственный интеллект в сфере кибербезопасности. Искусственный интеллект может помочь повысить вашу безопасность и обнаруживать атаки быстрее, чем когда-либо прежде, что делает его бесценным инструментом защиты ваших данных от злоумышленников. Интеграция искусственного интеллекта в кибербезопасности - это уже не далекая несбыточная мечта, а реальность, формирующая и укрепляющая защиту от постоянно растущих и изощренных киберугроз, нависших над цифровым миром.*
***Ключевые слова:*** *искусственный интеллект (ИИ), экспертная система, кибербезопаность, нейросеть, кибератаки, фишинг, хакеры, безопасность, цифровая среда, интернет, глобальная сеть – интернет.*

***Conceptual apparatus of artificial intelligence - Introduction.***

In today's fast-paced digital environment, artificial intelligence continues to make its mark on many areas, revolutionizing the way we live and work.

While expectations for the transformative impact of artificial intelligence are growing in many areas, there are some areas where it has already become a strong and integral part of the landscape. The integration of artificial intelligence into cybersecurity is no longer a distant pipe dream, but a reality that shapes and strengthens defenses against the ever-growing and sophisticated cyber threats looming over the digital world [6].

An artificial intelligence (AI) system is a software system that simulates the human thinking process on a computer. To create such a system, it is necessary to study the very thinking process of a person solving certain problems or making decisions in a specific area, highlight the main steps of this process and develop software that reproduces them on a computer. Consequently, artificial intelligence methods assume a simple structured approach to the development of complex software decision-making systems [5].

***Artificial intelligence*** is a branch of computer science whose goal is to develop hardware and software tools that allow a non-programmer user to set and solve their traditionally considered intellectual problems, communicating with a computer in a limited subset of natural language.

The idea of creating an artificial likeness of a person to solve complex problems and simulate the human mind, as they say, "was in the air" back in ancient times. The founder of artificial intelligence is considered the medieval Spanish philosopher, mathematician and poet Raymond Lull, who back in the 13th century tried to create a mechanical device for solving various problems based on the universal classification of concepts he developed.

Later, Leibniz and Descartes independently continued this idea, proposing universal classification languages for all sciences. These works can be considered the first theoretical works in the field of artificial intelligence.

However, the final birth of artificial intelligence as a scientific field occurred only after the creation of the computer in the 1940s, when Norbert Wiener created his seminal works on the new science of cybernetics.

The term "artificial intelligence" ("Artificial Intelligence" - English - "*Artificial Intelligence*") was proposed in 1956 at a seminar with the same name at Dartmouth College (USA). This seminar was devoted to the development of methods for solving logical (rather than computational) problems. Note that in English this phrase does not have that slightly fantastic anthropomorphic connotation that it acquired in the rather unsuccessful Russian translation. The word "*intelligence*" simply means "*the ability to reason intelligently*", and not "*intelligence*" at all (for which there is a separate English analogue "*intellect*").

Soon after artificial intelligence was recognized as a special field of science, it was divided into two areas: neuro-cybernetics and "black box" cybernetics. These areas developed almost independently, differing significantly both in methodology and technology. And, only now, trends towards combining these parts again into a single whole have become noticeable [1].

***Neuro-cybernetics.***

The main idea of this direction can be formulated as follows: "The only object capable of thinking is the human brain; therefore any thinking device must somehow reproduce its structure". Thus, neuro-cybernetics is focused on software and hardware modeling of structures similar to the structure of the brain. The efforts of neuro-cybernetics were focused on creating elements similar to neurons and combining them into functioning systems - neural networks [2].

The first neural networks were created in 1956–1965. These were not very successful attempts to create systems that simulate the human eye and its interaction with the brain. Gradually in 1970–1980. The number of works in this area of artificial intelligence began to decline - the first results were too disappointing.

Typically, the authors (inventors) of developments explained their failures by the small memory and low speed of the computers existing at that time.

The first neurocomputer was created in Japan as part of the "Fifth Generation Computer" project. By this time, restrictions on computer memory and speed were practically lifted. Transputers appeared - computers with a large number of processors that implement parallel calculations. Transputer technology is one of a dozen new approaches to the hardware implementation of neural networks that model the hierarchical structure of the human brain.

In general, today we can distinguish three main types of approaches to creating neural networks:

1) hardware (creation of special computers, neurochips, expansion cards, chipsets);

2) software (creation of programs and software tools designed for high-performance computers; such networks are created "virtually", in the computer's memory, while all the work is performed by its own processors);

3) hybrid (combination of the first two methods).

***Black box cybernetics and artificial intelligence.***

This approach is based on a principle opposite to neuro-cybernetics. Here it no longer matters how exactly the "thinking" device is structured - the main thing is that it reacts to the given input influences in the same way as the human brain.

Proponents of this trend motivated their approach by the fact that man should not blindly follow nature in his scientific and technological searches. In addition, the border sciences about man have not been able to make a significant theoretical contribution that explains (at least approximately) how intellectual processes occur in a person, how his memory works and how a person perceives the world around him [2, 5].

This area of artificial intelligence was focused on finding algorithms for solving intellectual problems on existing computer models. Significant contributions to the formation of the new science were made by such pioneers as McCarthy, Minsky, Newell, Simon, Shaw, Hunt and others.

In 1956–1963 Intensive searches were carried out for models and algorithms of human thinking and the development of the first programs based on them.

Representatives of the humanities - philosophers, psychologists, linguists - neither then nor now could offer such algorithms, then cybernetics began to create their own models.

Thus, various approaches were consistently created and tested.

At the end of the 1950s. a labyrinth search model appeared.

This approach represents the problem as a certain state space in the form of a graph, after which the optimal path from the input data to the resultant data is searched in this graph. A lot of work has been done to create such a model, but this idea has not yet found wide application for solving practical problems.

Early 1960s became the era of heuristic programming. A heuristic is a rule that is not theoretically justified, but allows you to reduce the number of searches in the search space. Heuristic programming is the development of an action strategy based on known, predetermined heuristics.

In the 1963–1970s. Methods of mathematical logic began to be used to solve problems. Robinson developed the resolution method, which allows one to automatically prove theorems given a set of initial axioms. Around the same time, the outstanding Russian mathematician Yu. S. Maslov proposed the so-called inverse derivation (later named after him), which solves a similar problem in a different way. Based on the resolution method, the Frenchman Albert Colmeroe created the logic programming language Prolog in 1973. The "Theoretical Logician" program, created by Newell, Simon and Shaw, which proved school theorems, caused a great stir in the scientific community.

However, most real problems cannot be reduced to a set of axioms, and a person, when solving production problems, does not always use classical logic, therefore, logic models, despite all their advantages, have significant limitations on the classes of problems being solved.

The history of artificial intelligence is full of dramatic events, one of which was the so-called "Lighthill report" in 1973, which was prepared in Great Britain by order of the British Research Council. The famous mathematician Lighthill, who is not professionally associated with artificial intelligence, prepared a review of the state of affairs in this area. The report acknowledged some achievements, but rated them as "disappointing" and the overall assessment was negative in terms of practical significance. This report set European researchers back about five years, as funding for the work was significantly reduced.

Around the same time, a significant breakthrough in the development of practical applications of artificial intelligence occurred in the United States in the mid-1970s. The search for a universal thinking algorithm was replaced by the idea of modeling the specific knowledge of specialist experts. The first commercial knowledge-based systems, or expert systems, appeared in the United States. A new approach to solving artificial intelligence problems has also begun to be used-knowledge representation. The first two expert systems for medicine and chemistry were created - Mycin and Dendral, which became classics. The Pentagon also made a significant financial contribution, proposing to base the new US Department of Defense program on the principles of artificial intelligence. Already catching up with missed opportunities, the European Union in the early 1980s. announced the global program for the development of new technologies ESPRIT, which included the issue of artificial intelligence.

At the end of the 1970s. Japan is joining the race, announcing the start of a fifth-generation knowledge-based machine project. The project was designed for ten years and brought together the best young specialists from the largest Japanese computer corporations. A new institute, ICOT, was specially created for these specialists and given complete freedom of action (*though without the right to publish preliminary results*). As a result, they created a rather cumbersome and expensive symbolic processor that implemented a Prolog-like language in software, but did not receive widespread recognition.

However, the positive effect of this project was obvious. In Japan, a significant group of highly qualified specialists in the field of artificial intelligence has emerged, which has achieved significant results in various applied problems. By the mid-1990s. The Japanese Association of Artificial Intelligence already numbered 40 thousand people.

Since the mid-1980s. The commercialization of artificial intelligence was taking place everywhere. Annual capital investments grew, and industrial expert systems were created. There was growing interest in self-learning systems. Dozens of scientific journals were published, international and national conferences were held annually in various areas of artificial intelligence, which was becoming one of the most promising and prestigious areas of computer science.

Currently, there are two main approaches to modeling artificial intelligence: machine intelligence, which consists in strictly specifying the result of operation, and artificial intelligence, aimed at modeling the internal structure of the system. Modeling of systems of the first group is achieved through the use of the laws of formal logic, set theory, graphs, semantic networks and other scientific achievements in the field of discrete computing, and the main results are the creation of expert systems, natural language parsing systems and the simplest control systems of the "*stimulus-response*" type. Systems of the second group are based on the mathematical interpretation of the activity of the nervous system (primarily the human brain) and are implemented in the form of neuron-like networks based on a neuron-like element - an analogue of a neuron [1, 3].

***Artificial intelligence in the USSR and Russia***.

Back in 1954, at Moscow State University named after M. Lomonosov, the seminar "Automata and Thinking" began under the leadership of Academician of the USSR Academy of Sciences A.A. Lyapunov (1911–1973), one of the founders of Russian cybernetics. This seminar was attended by physiologists, linguists, psychologists, and mathematicians. It is generally accepted that it was at this time that artificial intelligence was born in Russia. As well as abroad, two main directions have emerged - neuro-cybernetics and "black box" cybernetics.

In 1954–1964 separate programs were created and research was carried out in the field of finding solutions to logical problems. In the Leningrad branch of the Mathematical Institute named after. Steklov created the program "ALPEV LOMI", which automatically proves theorems, which is based on Maslov's original inverse derivation, similar to Robinson's resolution method. Among the most significant results obtained by domestic scientists in the 1960s, it should be noted the "Kora" algorithm by M. M. Bongard, which models the activity of the human brain in pattern recognition. Such outstanding scientists as M. L. Tsetlin, V. N. Pushkin, M. A. Gavrilov, whose students became pioneers of this science in the USSR, also made a great contribution to the development of the Russian school of artificial intelligence.

In the 1965–1980s. a new direction of artificial intelligence was born - situational (corresponding to the representation of knowledge in Western terminology). The founder of this scientific school was Doctor of Sciences, Professor D.A. Pospelov. Special models for presenting situations (representing knowledge) were also developed.

Despite the fact that the attitude towards new sciences in Soviet Russia was always wary, science with such a "provocative" name also did not escape this fate and was met with hostility at the Academy of Sciences. Fortunately, among the members of the USSR Academy of Sciences there were people who were not afraid of such an unusual phrase as the name of a new scientific direction.

However, only in 1974, under the Committee on System Analysis under the Presidium of the USSR Academy of Sciences, a scientific council on the problem of "Artificial Intelligence" was created, headed by Professor D.A. Pospelov. On the initiative of this council, five complex scientific projects were organized, headed by leading experts in the field: "Dialogue" (work on natural language understanding), "Situation" ("Situational Management"), "Bank" ("Data Banks"), "Constructor" ("Search Design") and ""Robot Intelligence".

In the 1980s–1990s. In our country, active research was carried out in the field of knowledge representation, knowledge representation languages and expert systems were developed; at Moscow State University. M.V. Lomonosov created the language "Refal".

In 1988, the Association of Artificial Intelligence (AI) was formed, the President of which was unanimously elected Professor D.A. Pospelov. Within the framework of this association, a large amount of research was carried out, schools for young specialists, seminars, symposiums were organized, joint conferences were held every two years, and a scientific journal was published.

It should be noted that the level of theoretical research on artificial intelligence in Russia has always been no lower than the global level. However, unfortunately, since the 1980s. The gradual lag in technology began to affect applied work. At the moment, the backlog in the development of industrial intelligent systems is approximately 3–5 years.

***The main areas of application of artificial intelligence systems***: "theorem proving", "games", "pattern recognition", "decision making", "adaptive programming", "composing machine music", "natural language data processing", "learning networks" ("neural networks"), "verbal conceptual learning", "vehicle autopilot" - air and ground transport, "smart homes", service at the household level in smart homes and much more.

***Directions for the development of artificial intelligence***.

The main direction of development at the timely stage of "Artificial Intelligence" is the representation of knowledge and the development of knowledge-based systems. It is associated with the development of knowledge representation models and the creation of knowledge bases that form the core of expert systems. Recently, this direction also includes models and methods for extracting and structuring knowledge and merges with knowledge engineering.

Traditionally, artificial intelligence includes gaming intellectual tasks - chess, checkers, crosswords, solving intellectual problems, etc. They are based on one of the earlier approaches - the labyrinth model (plus heuristics). Now this is more of a commercial direction, since scientifically these ideas are considered dead ends.

The next direction is the development of natural language interfaces and machine translation. In the 1950s One of the popular topics in artificial intelligence research has been the field of machine translation. The first computer program in this area was a translator from English into Russian. However, the idea of word-by-word translation used in it turned out to be unfruitful.

Currently, to solve such problems, a more complex model is used, which includes the analysis and synthesis of natural language messages and consists of several blocks.

The traditional direction of artificial intelligence, dating back to its very origins, is pattern recognition. Here, each object is associated with a matrix of features, which is used to recognize this object. This direction is close to machine learning and is closely related to neuro-cybernetics.

Such a direction as new computer architectures is engaged in the development of new hardware solutions and architectures focused on processing symbolic and logical data. Recent developments in this area focus on database computers, parallel computers, and neural computers.

***Another direction is intelligent robots***. A robot is an electromechanical device designed to automate human labor. The very idea of creating robots is extremely ancient (this includes, for example, medieval legends about "*golems*"). The word itself appeared in the 1920s and was invented by the Czech writer Karel Capek in his story "RUR". Currently, more than 60 thousand robots are manufactured in the world per year.

Robots with a rigid control scheme. Almost all modern industrial robots belong to this group and are actually programmable manipulators.

Adaptive robots with sensory devices. There are some examples of such robots, but they are not yet used in industry.

Self-organizing or intelligent robots. This is the ideal, the ultimate goal of the development of robotics. The main problem in creating intelligent robots is the problem of computer vision.

Within the framework of such a direction as special software, special languages are being developed to solve non-computational problems. These languages are focused on symbolic processing of information - *Lisp, Prolog, SmallTalk, Refal*, etc. In addition to them, application software packages are being created that are aimed at the industrial development of intelligent systems-artificial intelligence software tools. It is also quite popular to create so-called "*empty expert systems*" - "*shells*" that can be filled with knowledge bases, creating various expert systems.

Another actively developing area of artificial intelligence is learning and self-learning. This area includes models, methods and algorithms focused on the automatic accumulation of knowledge based on data analysis and synthesis, learning by example (or inductive), as well as traditional pattern recognition approaches.

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The emergence of the global Internet has had a significant impact on the development of the scientific direction “artificial intelligence” and vice versa.

The following existing and promising applications of artificial intelligence technologies on the Internet can be noted:

1) management of portals, large online stores and other complex web systems;

2) routing of information packets during their transmission over the network;

3) forecasting and optimization of the load on information transmission channels;

4) control of network robots[1], etc.

***Expert systems***.

In the early 1980s. In research on artificial intelligence, an independent direction has been formed, called “expert systems”.

“Expert systems” are complex software systems that accumulate the knowledge of specialists in specific subject areas and replicate this empirical experience to provide advice to less qualified users [4].

Researchers in the field of expert systems often use the term “knowledge engineering” to name their discipline, introduced by E. Feigenbaum and meaning “*the introduction of principles and research tools from the field of artificial intelligence into solving difficult applied problems that require expert knowledge*”. Software tools based on expert systems technology, or knowledge engineering, have become widespread in the modern world.

Expert systems differ from data processing systems in that they primarily use symbolic (rather than numeric) representation, symbolic inference, and heuristic search for a solution (rather than execution of a known algorithm).

Expert systems are able to expand their knowledge during interaction with an expert. Currently, expert systems technology is used to solve various types of problems (interpretation, prediction, diagnostics, planning, design, control, debugging, instruction, management) in a wide variety of application areas, such as finance, oil and gas industry, energy, transport, pharmaceutical production, space, metallurgy, mining, chemistry, education, pulp and paper industry, telecommunications and communications, etc.

***Development and use of expert systems.***

Representatives of the following specialties usually participate in the development of expert systems:

1) an expert in the problem area, the tasks of which will be solved by expert systems;

2) knowledge engineer - a specialist in the development of expert systems (the technology (methods) he uses is called knowledge engineering technology (methods);

3) a programmer for the development of tools designed to speed up the development of expert systems.

The expert determines the knowledge (data and rules) characterizing the problem area and ensures the completeness and correctness of the knowledge entered into expert systems.

A knowledge engineer helps an expert identify and structure the knowledge necessary for the operation of an expert system, selects tools that are most suitable for a given problem area, and determines the way knowledge is represented in this toolkit, identifies and programs (with traditional means) standard functions typical for given problem area, which will be used in the rules introduced by the expert.

The programmer develops an information system (structural) (if the toolkit is developed anew), containing all the main components of the expert system, and interfaces them with the environment in which they will be used.

It should be noted that the absence of knowledge engineers among the development participants (that is, their replacement by programmers) most often leads to the failure of the process of creating experimental systems, or significantly lengthens it.

An expert system can operate in two modes: in the knowledge acquisition mode and in the problem solving mode (also called the “*consultation mode*” or “*expert systems use mode*”) [1, 2].

In the knowledge acquisition mode, communication with the expert system is carried out (through the mediation of a knowledge engineer) by an expert. Using the knowledge acquisition component, he fills the system with knowledge that will later allow the experimental system, in solution mode, to independently (without an expert) solve problems from a specific problem area. An expert describes a problem area in the form of a set of data and rules, where the data defines objects, their characteristics and values that exist in the area of expertise, and the rules define methods of manipulating data that are characteristic of the area under consideration.

In consultation mode, communication with expert systems is carried out by the end user who is interested in the result and (or) the method for obtaining it. In this case, data about the user’s task, after being processed by the dialog component, enters working memory. The solver, based on input data from working memory, general data about the problem area and rules from the Database, generates a solution to the problem. Note that when solving a problem, the Expert System not only performs the prescribed sequence of operations, but also pre-forms it.

[1]**Network robots** (“*spiders*”) are intelligent agents that, starting from a certain set of links (“URL”) to web pages, recursively traverse Internet resources, extracting links to new resources from already received documents until some stopping condition will be met. In addition, network robots are special software modules that visit specified web resources and automatically download information posted on them.

In conclusion of the scientific article, we present from practical activities the main advantages of using artificial intelligence in **cybersecurity**:

1) ***Faster detection of key vulnerabilities***. AI-based solutions can quickly identify weaknesses in systems, reducing the opportunities for cybercriminals to exploit these vulnerabilities. Research shows that artificial intelligence can reduce the average time to detect vulnerabilities from weeks to hours or even minutes;

2) ***Improved risk identification and sound safety measures***. AI-powered analytics allows organizations to gain a deeper understanding of their security posture and implement targeted, data-driven security controls;

3) ***24/7 monitoring and threat reduction***. AI-powered cybersecurity tools provide automated 24/7 monitoring and can significantly reduce the average response time to security incidents, allowing organizations to more effectively prevent or limit the impact of breaches;

4) ***Reducing the burden on cybersecurity specialists***. Artificial intelligence automates routine tasks, freeing security professionals to focus on more complex tasks;

5) ***Increased efficiency and profitability***. AI-powered cybersecurity solutions streamline processes, minimize human errors and reduce reliance on manual labor;

6) ***Improved incident response***. AI-powered tools can analyze and prioritize security incidents, allowing organizations to respond to breaches more quickly and effectively;

7) ***Scalability and adaptability***. AI-powered cybersecurity solutions can adapt and scale to meet changing business needs, providing a more resilient and flexible security infrastructure that can grow with the organization;

8) ***Proactive threat search***. Solutions based on Artificial Intelligence can actively search for potential threats in an organization's digital environment, identifying and eliminating risks before they develop into full-scale attacks [7].

Therefore, as AI technology advances, it will become increasingly important for organizations to leverage AI in cybersecurity. Artificial intelligence can help improve security and detect attacks faster than ever before, making it an invaluable tool for protecting personal and other data, including state secrets, from attackers and other offenders.

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