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INFORMATION TECHNOLOGIES IN THE PARADIGM OF COGNITIVE SCIENCES

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The article shows the evolution of information technology based on the paradigm of cognitive sciences. The concepts of cognitive science related to the concepts of cognition, thinking, mathematical logic, functionalism, connectionism are analyzed. The role of information technology in the development of a decision-making methodology based on cognitive maps, the formation of a cognitive economy, the development of convergent technologies, the design of recursive, communicative connections in industry using industry 4.0 as an example is described.

Information technology is at the epicenter of attention because it has one of the key roles in scientific and technological progress in the 21st century. This role is designated as the fourth industrial revolution [1]. This revolution does not imply the abandonment of mankind of used energy sources, it focuses on the modernization of existing industrial, energy systems due to the convergence of cybernetic and physical systems. Information technologies will form integrated network structures for production and logistics, as well as new integrated technologies, industrial printers have become elements of which. Germany has developed a national industry strategy 4.0, which involves the practical transition of companies in the fourth industrial revolution [2]. Experts expect from this transition significant economic indicators of growth in the profitability of enterprises. At the level of national economies, the concepts of digital and network economies are actively used. Belarus has also developed a strategy for the development of economic structures in the direction of pairing them with the trend of the fourth industrial revolution. An important role in this strategy is given to the High-Tech Park.

Evolution is characteristic not only for industrial structures, but also for information technology. Cognitive science has become one of the platforms of this evolution [3]. This platform brought together sciences, the subject of which is cognition, interpreted as the acquisition, storage, transformation, use of knowledge by living and artificial systems. Among these sciences are experimental psychology, cognitive linguistics, mathematical logic, the theory of artificial intelligence, neurobiology, neurophilosophy.

Information technology was created in the twentieth century on the basis of the paradigm of functionalism. According to this paradigm, the description of functional properties and relationships is logically independent of the description of physical properties and relationships. This means that the same functions can be reproduced on substrates with different properties. In this context of consideration, human thinking is similar to mathematical calculation. It was only necessary to develop, within the framework of formal logic, the mechanisms necessary for programming to transform the statements of a natural language into the statements of an artificial language, one of the modifications of which is the language of mathematical calculi. Mathematical logic coped with this task. Human thinking was formalized on the basis of a specific set of functions for processing information, storing and transmitting information. At this stage, algorithms have been created for solving specific computational problems associated with statistics, costing, document management, design and construction. Human thinking was freed from routine arithmetic calculations similar to the function of a calculator. After the computers were combined into an information network, they began to perform the function of transmitting and receiving information (feedback). It turned out to be relevant in the face of increased volumes of information necessary for decision-making. It was the beginning of cybernetics.

But the developers of information technologies wanted to transfer more functions of human thinking to computer technologies. This means that in the description of the function of thinking it was necessary to introduce features of human consciousness. That was the beginning of the methodology of simulation modeling of information processing functions in the human mind. For this purpose, the conceptual apparatus of cognitive science has been updated. He became the basis of the paradigm of cognitive sciences. The initial thesis of this paradigm is that people act on the basis of cognitive codes [4]. Their behavior is a causal consequence of operations performed on the basis of these codes.

As a result of cognitive activity, a system of meanings (concepts fixed by the word) is created, which refers to the fact that the individual knows and thinks about the world. In a systematic form, these meanings are represented by a mentality, which is understood as a stable set of attitudes and predispositions of an individual or social group to perceive the world in a certain way. Mentality reflects the style of thinking, as well as mental attitude, national character, attitudes, values, behavior, activities, mental processes [5].

The subject of cognitive linguistics is the processes of perception, categorization, classification and understanding of the world, the accumulation of knowledge, that part of the information that is reflected and fixed in the forms of language. Frames (stereotypical situations, scenarios), concepts (the totality of all meanings expressed by the means of the language), gestalt (integral additional images of fragments of the world) became the instruments of operation. The language sign system plays a role in coding and transformation of information. Categorization develops concepts in which the most relevant properties for everyday consciousness are concentrated. Generative (transformational) linguistics of N. Chomsky has become one of the grounds for creating a new generation of computer programs that take into account the characteristics of subjective reality [6]. A native of Belarus from Belarus developed a transformational grammar. Its essence is that transformational and structural rules, principles describe the creation and of language expressions. Using a finite set of grammar rules and concepts, people can create an unlimited number of sentences. The ability to structure expressions is an inherent part of the genetic program of humans. They are practically unaware of these structural principles. People only need to learn lexical units and morphemes in order to construct expressions. Understanding the language is not due to past experience of behavior, but to the mechanism of language acquisition (internal memory structure).

J. Fodor developed the theory of human brain activity with the concept of the modularity of consciousness. According to this approach, the human cognitive system consists of a central processor and modules [7]. Central processors (conclusions) have access to the entire cognitive system of a person. They form censorship mechanisms. These mechanisms are culturally determined. Information that does not fit into cultural models does not reach the human mind, as it is censored. Censored (recognition, identity procedures) information is divided into modules (fragments). In the general semantic picture, it is collected only in the central processor. Information is structured to fit the cultural program.

In the theory of artificial intelligence, connectionism began to dominate. From the standpoint of connectionism, the mental activity of the brain is modeled through the distribution of activation signals between simple computational units (neurons), which make it possible in conditions of fuzzy or insufficient data, contextually dependent concepts, and dynamic representations. Neurons can enter quantitatively measured states of activation and measure the weight of connections with each other, creating complex systems, configurations, described by a mathematical apparatus. Each configuration described by a mathematical vector is a representation of a mental state. A neural network, unlike computers of linear architecture, practically does not need preliminary programming. She is capable of self-learning, as a result of which she performs the functions of generalization, classification, prediction, speech recognition, images, memory research, learning processes. In 2010, the Image Net database was developed. It contains 15 million images in 22 thousand categories. Based on such a database, a neural network is capable of making practically error-free decisions. Despite successes in the field of the theory of artificial intelligence, specialists were forced to admit that computer programs in the field of cybernetics only contribute to human decision making. He remains the main actor. Doubt was formulated in the isomorphism of the computer program and human consciousness. As a result, cognitive sciences have focused on the connection of the human psyche with the functions of his brain. Physical, psychological, and functionalism were combined. The result of concentration of efforts was psycholinguistics. A statement was formulated that organisms use internal representations (representations) and perform computational operations on them. Cognition in this sense is the controlled manipulation of representations.

The developers of the theory of behavioral economics and marketing began to believe that the understanding of the situation and decision-making by individuals is formed by mechanisms of unconscious thinking. D. Kahneman believes that the role of rational judgment is overestimated [8]. It focuses only a small part of the perceived information, reaching the stage of analysis. In many cases, a judgment on a positive outcome of a choice is made on the basis of a subjective opinion of its correctness, without taking into account real facts. Reflective thinking systems are knowledge-based. Impulsive thinking systems are based on off-the-shelf schemes.

The unconscious thinking model is preferred because it is highly effective due to the low consumption of intellectual resources. No additional cognitive effort is required. Activation of ready-made patterns of social relations occurs without the participation of consciousness (automatic thinking). When there are many variables, the brain performs mental tasks better without the participation of consciousness. When there are few variables and the solution of the problem is reduced to the simplest logical operations, conscious thought works. As a result, unconscious thought is wider than conscious thought due to the limited capacity of working memory. The neural system is a biological carrier and a causal generator of mental states. These conditions are identical to neural states. The spatial and environmental organization of the human nervous system is ontologically integrated into the brain and generates neural and mental states. A particular individual is a carrier of a mentalized brain. This means that mental states of consciousness are associated with neural processes in the human brain.

Maintaining the paradigm of cognitive sciences proved to be a rather difficult task amid criticism by its representatives of eliminative materialism. They believe that mental states do not exist, there are only neurophysiological events in the brain. There is no consciousness, there is only a functioning brain. But then the question arises, why the functioning of the human brain is accompanied by subjective experience and the function of free will. This gave rise to the proponents of the cognitive science paradigm to operate with variations of the solution to the problem of bodily-mental dualism in the latest analytical philosophy.

Whatever further solutions of this theoretical question were proposed by philosophy, modeling of the development of the situation under various control influences (strategies) and the subsequent comparative analysis of forecasts of the development of the situation became relevant. This approach involves cognitive analysis and management of the development of the situation, decision support in poorly structured subject areas, situation analysis and assessment of alternatives, multi-criteria hierarchical assessment of situations using computer modeling, analysis of influences in the management of poorly structured situations, intellectual support for management decisions.

A methodology for modeling subjective representations of experts about the situation has been developed. It involves a structured situation. A model is created for representing the expert's knowledge in the form of a sign graph (cognitive map). It reflects many factors of the situation and many causal relationships between the factors of the situation. During its testing, methods of analysis of the situation, maps of spatial correlations, trend surfaces, density fields and intensity of phenomena are used. A similar methodology is provided by the integration of cartography, geoinformatics, and remote sensing.

The seeming shortcomings of the mental structures of individual consciousness should not be ignored, but incorporated into constructive decision-making models.

B. Kosko [9] proposed a methodology for ensuring decision making in conditions of limited rationality and subjective experience. The methodology is based on fuzzy logic. The basis of this logic was formed by the apparatus of the theory of fuzzy sets. Based on the relationship of fuzzy logic and the theory of neural networks, intelligent expert systems have been created. A theorem is proved according to which any mathematical system can be approximated by a system based on fuzzy logic.

A methodology for cognitive modeling based on the use of cognitive maps has been developed. Cognitive modeling allows you to explore the evolution of the situation in the enterprise on the parameters of marketing, production, logistics, external influences, the targeted development of business planning. A cognitive map is an iconic directed graph. Its structure is formed by many vertices (concepts) and arcs (cause-effect relationships). The purpose of cognitive modeling is to generate and test hypotheses about the functional structure of the observed situation at the enterprise. Cognitive maps contribute to the formation and refinement of the risk hypothesis.

The cognitive map contains the laws of the observed situation known to the decision-maker in the form of an oriented sign graph. The vertices of the graph are factors, signs, characteristics of the situation in the enterprise. Arcs characterize causal relationships between vertices. Cognitive modeling is applied to complex situations of crisis management and crisis management. Computer systems for modeling cognitive maps have been developed. This is important from the point of view of modeling transitions between reference situations in complex systems under conditions of uncertainty.

The logical development of traditional cognitive maps is fuzzy cognitive maps proposed by B. Kosko. These cards are presented in the form of a fuzzy oriented graph with feedback, the nodes of which are fuzzy sets. The stages of cognitive modeling are methodologically substantiated. At the first stage, target factors are distinguished, the values of which must be brought into the required form. Cognitive-targeted structuring of knowledge is carried out. The factors characterizing the strengths and weaknesses of the enterprise, as well as factors characterizing the opportunities and threats from the external market environment are highlighted. The construction of a problematic field of enterprise development is being carried out. A cognitive model of enterprise development is being built on the basis of formalization of knowledge obtained at the stage of structuring. Factors are identified and justified. The relationships between factors are established and substantiated. A graph model is being built.

Scenarios of researching the development trends of the situation in the enterprise are formulated through determining the purpose of its modernization. Situation management strategies are being developed. Formalization of decision-making processes is designed to ensure decision-making, but not to replace them. First of all, it is supposed to support decision-making based on poorly structured information; assessment of the situation and assessment of alternatives. A multi-criteria hierarchical assessment of the situation is implemented. The analysis of influences in the management of poorly structured situations is carried out. The methods of formation of enterprise development scenarios are used.

Cognitive maps are built in an expert way. Experts, analysts use ideas about the processes occurring in dynamic situations at the enterprise. They use scenarios for the development of the situation in the enterprise in rapidly changing conditions and correlations.

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