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ARTIFICIAL INTELLIGENCE: ESSENCE, PRINCIPLES OF WORK, PERSPECTIVES OF DEVELOPMENT

Abstract. *The article considers the ontology of artificial intelligence (AI) development, its essence, principles of construction and areas of application, as well as the prospects of its development. The analysis shows that AI cannot replace human intelligence, which, in addition to cognitive abilities, includes spiritual, moral and ethical aspects that determine its behaviour in the surrounding world. Artificial intelligence is an intellectual robot, a machine taught by a human to perform some of its functions. The prospects for the development of artificial intelligence will be significant. Already now, AI is being tried on particularly effectively in many areas. Experts estimate that AI technologies will increase the efficiency of digital transformation by six to seven times, and the speed of obtaining public services thanks to them will increase by 10 times by 2025.*

Keywords: *human intelligence, artificial intelligence, principles of AI operation, essence and role of AI, prospects of AI application.*

Introduction

Scientific and technological progress (STP), reflecting the direction and dynamics of human civilisation development, has always been aimed at obtaining new knowledge, technologies and the creation of machines based on them,

reducing the energy consumption of human labour. In its development NTP has passed four stages: mechanisation (late XVI - early XVIII centuries), when heavy physical labour was gradually performed by mechanisms and machines; automation (late XIX and mid XX centuries), which provided the replacement of uniform and repetitive manual operations by automatic devices with minimal participation of humans; computerisation (mid XX century) - the introduction of computer technology in virtually all spheres of human activity, which provided a reduction in the time and number of employed workers, improving the quality and comfort of the workplace; computerisation (mid XX century) - the introduction of computer technology in virtually all spheres of human activity, which provided a reduction in the time and number of employed workers, improving the quality and comfort of the workplace. The late 20th and early 21st centuries were marked by the introduction of artificial intelligence (AI) in automated control systems of various processes, the creation of robotic systems based on it, which perform many human functions in production, transport, ensuring the safety of personnel and the environment from the possible occurrence of catastrophic situations. All four stages of NTP represent a single and inseparable process of human civilisation development, when all innovations (new knowledge, technologies and new techniques) appear on the foundation of past achievements. The next stage, which has already begun, is intellectual robotisation, which will lead to a significant change in the role, content and significance of human labour, and thus of man himself in all spheres of life. And here arises a far from idle question - what will happen to Man? What functions will he fulfil in the near future? Will artificial intelligence replace Man's mind? In this article the authors make an attempt to answer these questions. Further we will consider the definitions of artificial intelligence, its essence and properties, as well as the principles of its formation and areas of its application.

Methodology

Artificial Intelligence is a model of the decision-making process of natural intelligence (human). It is based on a cybernetic model for processing information to make decisions. Distinctive properties of human intelligence from artificial intelligence are:

- realisation of its intelligence as a mind through the prism of moral, ethical, social categories and norms (responsibility, understanding of duty, sociability, benevolence, impossibility of harming the environment, including humans, etc.);
- goal-setting, i.e. the ability to form goals, set tasks and choose criteria for their achievement in the process of its functioning taking into account consciously accepted moral and ethical norms;
- the ability to perform creative functions that are not reduced to copying, plagiarism, repetition of known results in such fields as science, music, literature, theatre, cinema, etc.; the ability to perform creative functions that are not reduced to copying, plagiarism, repetition of known results in such fields as science, music, literature, theatre, cinema, etc.; and

- the presence of ‘insight’. Artificial intelligence does not and cannot have a soul, a receptacle of spirit and morality, and this is its main difference from humans [1].

It is also unclear whether AI will be able to create communities of its own kind and develop a system of relations between them and the surrounding world. Common features of human and artificial intelligence are the following properties:

- The presence of channels of communication with the external environment and obtaining the necessary information to fulfil assigned functions;

- learning (with or without a teacher) to create the knowledge base necessary to fulfil its functions;

- ability to solve complex logical and formalised tasks related to classification of objects, ordering of alternatives, search for the best alternative according to given criteria, identification of trends in changing processes;

- analyse the results of their decisions (actions) and correct the algorithms of their implementation;

- store programmes and algorithms of functioning in memory and protect them from external influences. At the same time, AI possesses a number of properties that are absent or limited in human intelligence:

- ability to store large arrays of heterogeneous information in its memory and process it at high speed;

-the transition to quantum computer systems in general removes the problem of memory and speed of AI systems;

- round-the-clock and all-weather operability of AI using only one type of energy;

- absence of human ‘passions’ and ‘vices’ interfering with the work, although the possibility of a conflict between AI and humans is not excluded.

From the above definitions, it is clear that AI is created by Man and is the highest achievement of his intelligence. Artificial intelligence cannot claim to completely replace the natural intelligence, i.e. Man. Yes, AI capabilities can be higher and fuller than the intellectual capabilities of an average human being, since its development involves high-level specialists from various fields of science and technology: mathematicians, cyberneticians, information scientists, engineers, as well as linguists, psychologists, pedagogues, sociologists and others. But artificial intelligence is a derivative of natural intelligence, which means that it cannot exceed it. Modern science has not yet reached the understanding of all the possibilities of human intelligence, much less its limits [1; 2].

Literature review

The first discoverers and researchers of artificial intelligence are famous foreign scientists: A.Turing, K.Shannon, N.Wiener, J.McCarthy, D.Hinton, J.von Neumann, F.Rosenblatt, S.Pipert and others. J.McCarthy is rightfully considered not only the author of the term, but also the founder of the scientific direction and the leader of the first project in the field of artificial intelligence. In the USSR, work on artificial intelligence began in 1974 and was headed by Academician G.Pospelov6 , on whose initiative the section ‘Artificial Intelligence’ was organised as part of the Scientific Council of the Presidium of the USSR Academy

of Sciences on the complex problem 'Cybernetics'. In 1988, the First All-Russian Conference on Artificial Intelligence was held at the Institute of the USSR Academy of Sciences in Pereslavl-Zalessky, where the results of the work of Soviet scientists in this area were summarised. The results of the conference were published in 11 volumes and also in a number of subsequent monographs [3; 4]. Prominent Soviet and Russian scientists took an active part in the works on artificial intelligence: N.Moiseev, V.Glushkov, D.Pospelov, V.Solodov, A.Lyapunov, V.Khoroshevsky, E.Efimov, A.Ehrlich and others.

Results

All achievements in the field of mathematics, logic, mathematical and heuristic modelling, computer science, linguistics, psychology and pedagogy are widely used for the development of intelligent systems and computer programs. Modern technologies of AI construction and means of their computer implementation allow realising various conceptual approaches in creating SII. Let us consider some of them in historical retrospect.

Symbolic approach

Historically, the symbolic approach was the first in the era of digital machines, as it was after the creation of the machine language LISP (author J.McCarthy), the first language of symbolic computations, that confidence in the possibility of practical realisation of artificial intelligence arose. The symbolic approach allows to operate with weakly formalised representations and their meanings [3; 5]. However, the success and efficiency of solving new problems depends on the ability to isolate only essential information, which requires experience and flexibility in abstraction methods. An ordinary computer programme establishes its own way of interpreting data, which makes its work look biased and purely mechanical. The intellectual task in this case is solved only by a human being, analyst or programmer, not knowing how to entrust it to a machine. As a result, a single model of artificial intelligence is created - a system of constructive entities and algorithms. And flexibility and versatility result in significant expenditure of resources and use of human intelligence.

Logical approach

The logical approach to the development of artificial intelligence systems is based on modelling of reasoning. The theoretical basis is logic and logical-algebraic models [5; 6]. The logical approach can be illustrated by the application of the PROLOG language and logic programming system for these purposes [7; 12]. Programmes written in the PROLOG language represent sets of facts and rules of logical inference without rigidly specifying the algorithm as a sequence of actions leading to the required result.

Hybrid approach

The hybrid approach suggests that only a synergistic combination of neural and symbolic models achieves the full range of cognitive and computational capabilities. For example, expert inference rules can be generated by neural networks, while generating rules is obtained through statistical learning. Proponents of this approach believe that hybrid information systems will be significantly more powerful than the sum of the various concepts in isolation.

Knowledge Engineering

The knowledge engineering direction combines the tasks of knowledge acquisition from simple information, its systematisation and use [3,8,9]. This direction is historically connected with the creation of expert systems - programmes that use specialised knowledge bases to obtain reliable conclusions on any problem. Knowledge production from data is one of the basic problems of data mining. There are various approaches to solving this problem, including those based on neural network technology, using procedures of neural network verbalisation.

Machine learning

Machine learning concerns the process of independent knowledge acquisition by an intelligent system in the process of its operation. The field of machine learning includes a large class of tasks on pattern recognition (symbols, text, speech, computer vision). This area has been central from the very beginning of the development of artificial intelligence [3; 5,]. In 1956, at the Dortmund Summer Conference, R. Solomonoff wrote a report on a probabilistic machine learning without a teacher, calling it the Inductive Inference Machine [8,11]. Learning without a teacher allows recognising images in the input stream. Learning with a teacher also includes classification and regression analysis.

Intelligent Robotics

The fields of robotics and artificial intelligence are closely related. Integrating these two sciences, the creation of intelligent robots constitutes another area of artificial intelligence. Intelligence is required for robots to manipulate objects, perform navigation with localisation problems (locate, explore nearby areas) and motion planning (how to get to the target) [10,13]. Currently, many real-world examples of intelligent robots are known to be used in industry, commerce, service and performing specialised functions.

Machine creativity

The nature of human creativity is even less studied than the nature of intelligence. Nevertheless, this field exists, and the problems of computer writing of music, literary works, and artistic creation have been posed here. Creation of realistic images is widely used in cinema and computer games industry. The study of problems of technical creativity of artificial intelligence systems stands out separately. The theory of inventive problem solving, proposed in 1946 by G. Altshuller, laid the foundation for such research. Adding this capability to any intelligent system allows to demonstrate very clearly what exactly the system perceives and how it understands it.

Artificial Intelligence System Structure and Models

From the above definitions and the functions and tasks attributed to the prerogative of AI, it follows that the minimum necessary structural and functional elements of AI systems (AIS) are:

interface, database, knowledge base, knowledge base, inference base.

Figure 1 schematically shows the structure of the AIS. Bidirectional arrows show forward and backward communication channels between the AIS elements.

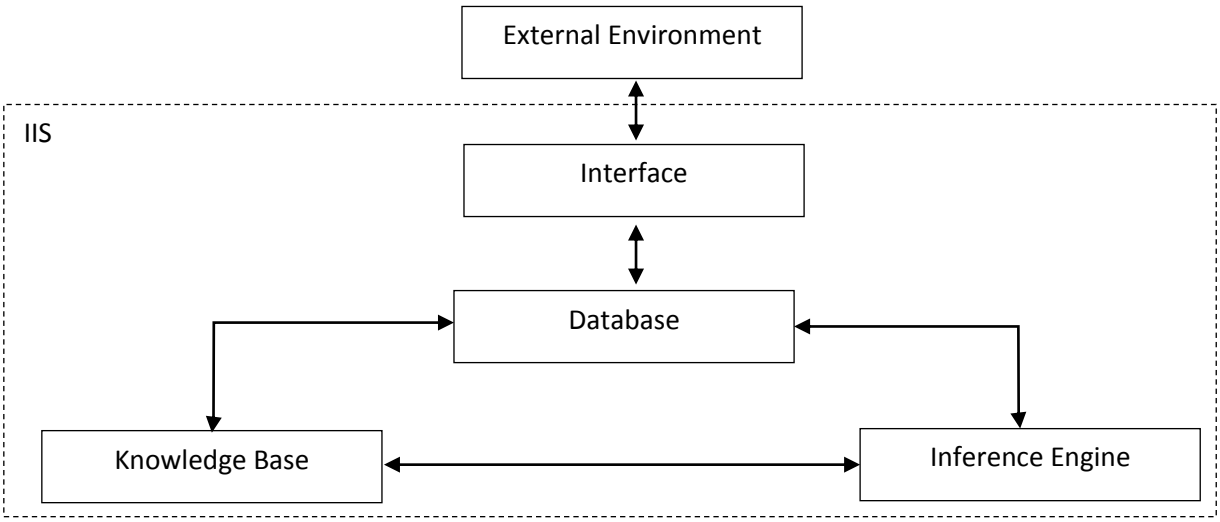

Figure 1 – Structural Diagram of AIS

Each element of the AIS represents subsystems of logical-mathematical, procedural, frame and semantic models describing the properties of objects, their relations and connections, interaction processes, criteria and methods of analysing and predicting their impact on the external environment. Due to the complexity of these processes, an ASI can solve these problems in relation to a specific subject area or a limited group of such areas. Like Man, the artificial intelligence cannot cover the whole universe due to the limitations of its capabilities.

Database (DB) is an information model of a certain subject area of the external world, contains all necessary facts, phenomena, processes and characteristics of objects in the dynamics of their existence, as well as algorithms for managing this data to solve applied problems. A database is built on the basis of a data model, which describes with the help of special languages the structure of data, their attributes (attributes) and information relations. Hierarchical, network and relational (tabular) databases are distinguished by the type of structure. The simplest and most natural form of data description is the relational model, which allows using algebraic operations on data (attributes and their relations) as some sets. Hence, the concept of relational algebra emerged [5,14].

Relational algebra operates not only with unambiguous sets and variables, but also with fuzzy (fuzzy) sets and relations. The database may include a database of goals, which is formed by a Person. The base of goals includes their formalised description, necessary resources, criteria of achievement, as well as permissible restrictions. The knowledge base (KB) includes:

- information about the structure and content of the database;
- information and mathematical models describing relations and regularities of interaction of objects of the subject area both at the current moment of time and in the dynamics of change, forecasting of potentially possible states and methods of their quantitative assessment;
- information and mathematical models of adaptation of available knowledge in case of changes occurring in the database.

When creating a BR, knowledge models are used, represented in declarative, procedural and special forms. The declarative ones include productive, reductive and predicate models. Productive models represent some set of statements (axioms), which are performed independently of the subject area and new statements deduced from them by means of theorems. A theorem is a logical formula of inference with the help of certain rules (procedures). Reductive models realise knowledge representation in the form of some composition of private productive models (lemmas), formation of a theorem on their basis and derivation of a new statement.

In productive and reductive models of knowledge the initial data remain unchanged, and only axioms and theorems change, which are fully determined by the subject area (mathematics, physics, engineering, economics, etc.).

Predicate models form a knowledge base in the form of relations between operating objects, in which the corresponding axioms, lemmas, formulas are already taken into account. A predicate in this case is a correctly constructed formula that provides a true statement. The number of predicates (universal formulas) is usually less than the number of axioms, lemmas, formulas in declarative and reductive models. In this case, the use of predicates reduces the required memory of the KB and simplifies its formalised description.

Procedural knowledge models are based on the development of a special knowledge representation language (KRL). This language uses both declarative and productive knowledge models, on the basis of which a hybrid information unit frame was created. A frame is a semantic-syntactic block containing declarative and procedural description of information. The links between frames are specified by means of networks (directed graphs). Hence the semantic network, a universal module of modern intelligent systems, emerges. A typical representative of the NLP built on semantic networks using frames is the PLANNER language and its modifications. Procedural models using frames and realising mechanisms of relational algebra relations, fuzzy sets and inference, neural network models are referred to special knowledge models [5; 6]. These models are getting closer and closer to the ways of organising human cognitive activity and thinking.

The inference rule base contains algorithms for inferring new knowledge in procedural-declarative form, in the form of relational algebra, in the form of frames, semantic and neural networks. The principles of construction and algorithms of functioning of the structural elements of the ISS are described in more detail in [3,5, 8, 9].

Future prospects for development

Computerisation, which has encompassed almost all aspects of life, has made it difficult to analyse and process large amounts of data. Data warehousing, operational analytics and cloud computing have been created in response to this need. Global IT leaders are racing to create processes that train neural networks in order to remove the responsibility of data processing from humans.

Without the active development of AI systems, the development of robotics is not possible. Therefore, large corporations are investing billions of dollars to develop control systems for unmanned vehicles.

Investments in the development of AI by major world powers will lead them to improve their economies, in particular, GDP growth, as it was in the USA after the decoding of the human genome [9].

It is also expected that the development of artificial intelligence will lead to the improvement of market relations, management system, human resource planning system. And especially dramatic changes in the business management model of many organisations are expected.

Prospects for the development of artificial intelligence although have inflated expectations from the world communities, but one way or another, the level of AI development will be significant. Already, AI is being tried on particularly effectively in many areas. Experts estimate that AI technologies will increase the efficiency of digital transformation by six to seven times, and the speed of obtaining public services thanks to them will increase by 10 times by 2025 [10].

Conclusion

Consideration of the ontology of the term artificial intelligence and the essence reflected by it as a direction of science and technology development allows us to draw the following conclusions.

1. Artificial intelligence is a section of interdisciplinary science and technology related to giving technical systems some abilities inherent in human intelligence in a particular subject area. Artificial intelligence emerged and develops on the basis of fundamental scientific disciplines such as mathematics, mathematical modelling of cognitive processes, informatics (theory and methods of information analysis), linguistics, psychology, theory and methods of learning. The technical and technological basis of artificial intelligence is computers and their software (algorithms, programming languages, interfaces).

2. Artificial intelligence is a derivative of human intelligence, which means that it cannot in principle surpass it due to the lack of self-consciousness, the ability to goal-setting, creative insight, soul - the receptacle of spirit and morality. Artificial intelligence, in essence, is an intellectual robot.

3. The capabilities of artificial intelligence can surpass those of the average person in a particular subject area. Therefore, the application of AI is justified and useful for use in various subject areas.

4. The application of artificial intelligence in military and special operations where there is an immediate threat to human life is necessary and justified. Lagging behind in this area is the greatest threat to national security.

5. It is an absolute necessity to successfully implement the standardisation programme in the direction of ‘Artificial Intelligence’ of the federal project ‘Artificial Intelligence’, including both metrological standards and standards that establish requirements for industry-specific data sets, covering among others the sectors of public administration, health care, transport, environment, industry, education, construction, communications, agriculture, fuel and energy complex. An urgent task is the development of a standard for the use of AI in military affairs, in weapon designs and complexes, automated systems of troop control, in the education and training of military specialists in the field of AI systems.

6. The prospects of artificial intelligence have been clearly defined in the business sphere for a very long time. Gradual involvement of several subject areas in the general flow of artificial intelligence development is capable of developing it to an incredibly high level of thinking on the basis of molecular bioelectronics, informatics, theoretical biology and quantum theory.

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ЖАСАНДЫ ИНТЕЛЛЕКТ: МӘНІ, ҚЫЗМЕТ КӨРСЕТУ ПРИНЦИПТЕРІ, ДАМУ БОЛАШАҒЫ

Аңдатпа. *Мақалада жасанды интеллект (АИ) дамуының онтологиясы, оның мәні, құрылыс принциптері мен қолдану салалары, сондай-ақ оның даму перспективалары қарастырылған. Талдау көрсеткендей, АИ адам интеллектін алмастыра алмайды, ол когнитивтік қабілеттерден басқа, қоршаған әлемде адамның мінез-құлқын анықтайтын рухани, моральдық және этикалық аспектілерді қамтиды. Жасанды интеллект - бұл интеллектуалды робот, адам өзінің кейбір функцияларын орындауға үйретететін машина. Жасанды интеллект дамуының болашағы зор болады. АІ қазірдің өзінде көптеген салаларда әсіресе тиімді қолданылуда. Сарапшылардың пікірінше, АІ технологиялары цифрлық трансформацияның тиімділігін алты-жеті есеге, ал мемлекеттік қызметтерді алу жылдамдығы 2025 жылға қарай 10 есеге артады.*

Түйінді сөздер: *адам интеллектісі, жасанды интеллект, ЖИ жұмыс істеу принциптері, ЖИ мәні мен рөлі, ЖИ қолдану болашағы.*

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ИСКУССТВЕННЫЙ ИНТЕЛЛЕКТ: СУЩНОСТЬ, ПРИНЦИПЫ РАБОТЫ, ПЕРСПЕКТИВЫ РАЗВИТИЯ

Аннотация. *В статье рассмотрена онтология развития искусственного интеллекта (ИИ), его сущности, принципов построения и областей применения, а также перспектив его развития. Проведенный анализ показывает, что ИИ не может заменить интеллект человека, который помимо познавательных способностей, включает в себя духовно-нравственные и этические аспекты, определяющие его поведение в окружающем мире. Искусственный интеллект – это интеллектуальный робот, машина, наученная человеком выполнять некоторые его функции. Перспективы развития искусственного интеллекта будут значительными. Уже сейчас во многих областях ИИ примеряется особенно эффективно. По оценке экспертов, технологии ИИ позволят увеличить эффективность цифровой трансформации в шесть-семь раз, а скорость получения государственных услуг благодаря им к 2025 году вырастет в 10 раз.*

Ключевые слова: *интеллект человека, искусственный интеллект, принципы работы ИИ, сущность и роль ИИ, перспективы применения ИИ.*