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THE POSSIBILITIES OF ARTIFICIAL INTELLIGENCE IN THE FORMATION OF INNOVATIVE AND TECHNOLOGIVAL FORECAAND

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ANNOTATION

Artificial intelligence is increasingly penetrating into the all spheres of our life, and in the nearest future most of the technologies used will have signs of artificial intelligence. It has already been widely used in the formation of social and economic forecasts, as well as in forecasting various natural phenomena and the impact of human and industrial processes on the environmental situation. However, the issue of using artificial intelligence in scientific and intellectual forecasting has been poorly studied and it requires deeper theoretical and methodological substantiation. The purpose of the study was to find effective approaches to

the use of artificial intelligence technologies in the formation of long-term forecasting of the development of science, techniques and technologies. The main method of research was to use an integrated and systematic approach to the analysis of domestic and foreign publications on the use of artificial intelligence technologies in the formation of scientific and technological forecasts and the adaptation of the most effective of them to the peculiarities of the formation of technological forecast in Russia. The structure proposed by the authors is the use of artificial intelligence technologies at the stages of scientific and technological forecasting. Description of the possibilities of using individual artificial intelligence technologies in scientific and technological forecasting are presented. The prospect of using artificial intelligence technologies in the formation of scientific and technological forecasts are shown. The novelty of the presented results is that for the first time the authors describe the possibilities of using the most appropriate and effective artificial intelligence in the formation of long-term forecasts of the development of science, techniques and technologies in Russia from the standpoint of systematic and integrated approaches.

Keywords: artificial intelligence, innovative and technological forecasting, technologies of artificial intelligence, stages of forecasting, effectiveness

INTRODUCTION

Artificial intelligence (AI) is increasingly penetrating in all spheres of our life influencing technologies used, including AI forecasting technologies. AI will be applied on the most of corporative digital platforms and in digital tools used by enterprises. It will allow to increase considerably technological processes and improve quality of fulfilment. Due to artificial intelligence technology up to the year 2030 the world economics level will have been increased for 15,7 trillion of US dollars. At the same time for active introduction of AI technologies development of scientific and technological apparatus and practical recommendations is required. They will allow to heads of the companies to introduce AI both within separate pilot projects and in the scales of the company [1],

Gartner asserts that this year 80% of new technologies will have been developed on the AI basis and by 2023 AI as well as the methods of deep learning will change the traditional machine training [2].

AI is able to combine various methods and approaches to solving problems that aren't connected or loosely interconnected. In the course of creating new e-technologies AI uses the achievements of science and technology that form the new sixth technological order:

genetic engineering, biotechnologies, nanotechnologies, robotics, and digital technologies and telecommunication networks of a new generation.

The main part of the article. The most widespread AI technology used in forecasting is the technology of artificial neural networks based on the principles of the human brain [3]. Artificial neural networks in combination with the Holt method allow solving problems of forecasting financial activity, e.g., increasing the exchange rate, stock quotes, metal and oil prices, etc. [4]. In this case, the Holt method is used for time series that tend to rise or fall [5].

AIU is used to predict oceanic mesoscale phenomena of typhoon cold awakening occurring in the northwestern Pacific Ocean [6] as well as in predicting daily runoff time series for sustainable water management [7]. Accurate runoff forecasting plays an important role in ensuring the sustainable use and management of water resources. AI methods can provide new opportunities for predicting runoff when the underlying physical relationship can't be obtained obviously. However, today it is extremely rare to assess the effectiveness of various AI methods in predicting daily runoff time series for sustainable water management. To fill this gap in research the possibilities of five AI methods in predicting daily series of flows are considered including artificial neural method (ANN), adaptive fuzzy inference system based on neural networks (ANFIS), extreme learning machine (ELM), Gaussian process regression (GPR)(and support vector machine (SVM). AI methods are used to predict air pollution by generalizing empirical knowledge about air pollution based on AI. Most traditional forecasting methods have shown inconsistent forecasting accuracy due to the nonlinear, dynamic and complex nature of air pollutants. In the last few years methods based on AI have become the most powerful and promising approaches to predicting air pollutions due to their specific features, such as organic learning, high accuracy, excellent generalization, high fault tolerance and ease of working with high dimensional data [8].

AI is even used to predict COVID-19 outbreaks in Russia and Brazil. Predicting COVID-19 cases in hot spots is a critical issue as it helps policy makers to develop their plans for the future. Currently, a new model of short-term forecasting has been developed using an improved version of the adaptive neuro-fuzzy inference system (ANFIC). An improved Marine Predator Algorithm (MPA), called Chaotic MPA (CMPA) is applied to improve ANFIS and

eliminate its shortcomings. Comparison of the CMPA model with three models and two modified versions of the ANDIS model using both the original marine predator algorithm (MPA) and particle swarm optimization (PSO) showed that the prediction accuracy of the CMPA model significantly exceeded all other models studied [9].

Due to the widespread adoption of solar energy for a sustainable and renewable future, the stochastic and volatile nature of solar energy poses significant challenges to the reliable economic and safe operation of power supply system. Therefore, it is extremely important to improve the accuracy of solar energy forecasting in order to prepare for unknown conditions in the future. Until now AI algorithms such as machine learning and deep learning have been wisely publicized with competitive prediction efficiency, as they can reveal invariant structure and nonlinear features in solar data. A taxanomic study on existing models for predicting solar energy based on AI algorithms is of interest. Naxonomy is the process of systematically dividing solar energy forecasting methods optimizers and forecasting systems into several categories based on their differences and similarities. This approach can help scientists and engineers theoretically analyze the characteristics of various models for predicting solar activity, thereby helping them to choose the most appropriate model in any application scenario [10]. Hybrid AI models are used to improve prediction accuracy by minimizing uncertainties in the prediction environment [11], by integrating the Grey Wolf Optimization Algorithms (GWO) with AI models [12] or combining grey prediction (GM) and the grey Markov – Fourier prediction model (MFGM) to develop an expert diagnostic system using AI that improves the prediction efficiency of randomly changing data [13]. The theoretical basis concerning the possibilities offered by modern applications of AI tools, especially artificial neural networks in the field of materials science is presented in the work of the authors of their Silesian University of Technology, including modeling of various properties of engineering materials [14]. An innovative project on the introduction of artificial neural networks to predict trends in the development of material surface treatment technology is discussed separately.

From Russian research, the use of cognitive systems for monitoring and forecasting the scientific and technological development of the state is of interest [15]. The authors show the possibilities of using algorithms or the integrated assessment of

scientific and technological projects based on cognitive technologies (evolutionary algorithms, fuzzy neural networks), and also the possibilities of using neuro-fuzzy algorithms for modeling the change of technological patterns and cognitive assessment of priority areas of scientific and technological development of the state.

One of the priorities in the formation and use of scientific and technological forecasts is the structure of AI technologies in terms of its use.

The structure of art functions performed by technologies is shown in Figure 1.

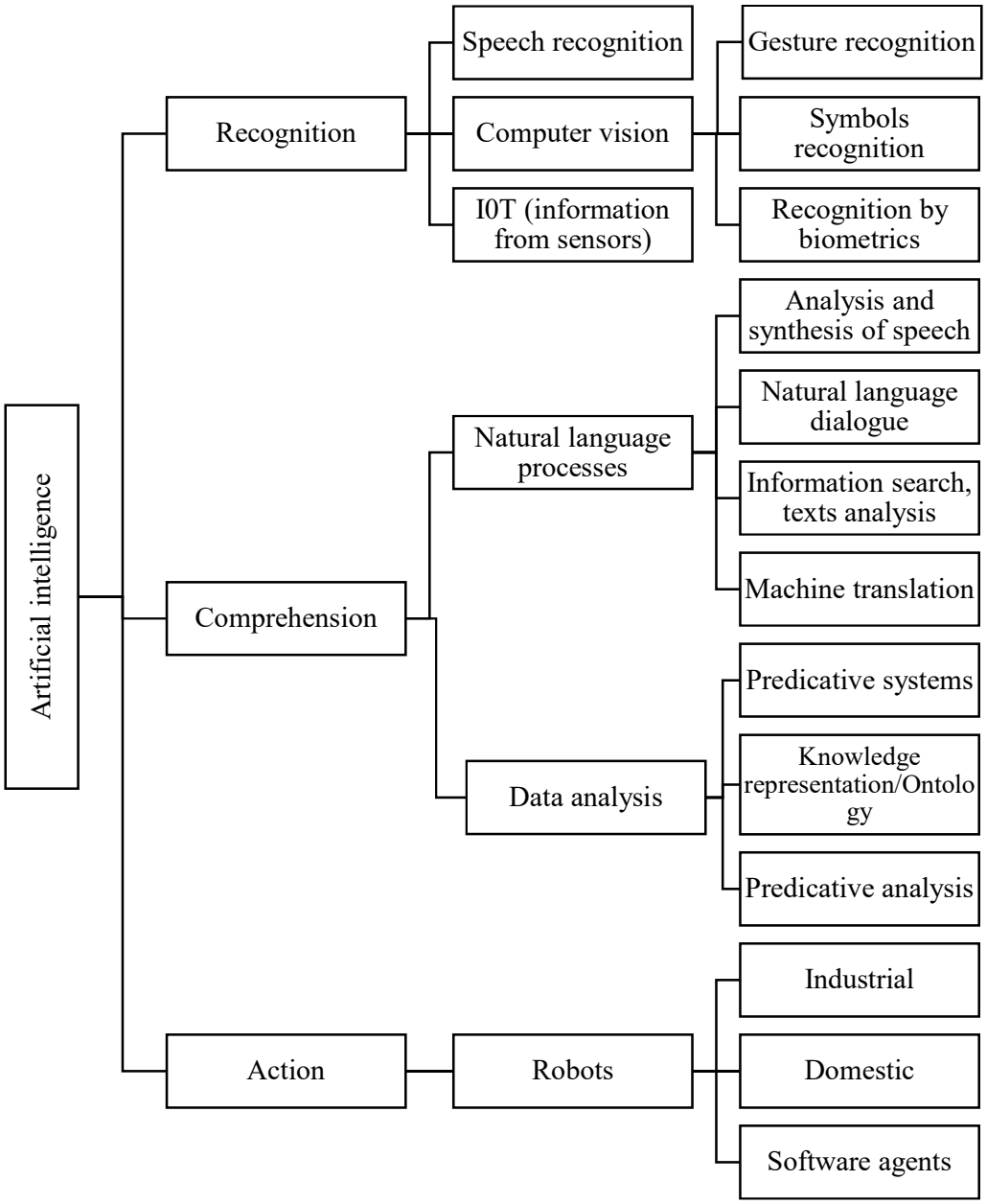

Figure 1: The structure of art functions performed by technologies

The most relevant trend in the development of AI is computer vision which is a set of AI technologies for solving recognition problems by processing various images, and the recognition quality is many times higher than human vision. Processing satellite images searching for information on photography in big data basis, character recognition, etc. can be effectively used in the formation of scientific and technological forecasts.

An important trend is the possibility of using AI in scientific and technological forecasting. From the point of view of applying the methodology of AI to the tasks of forecasting the development of science and technology the following methods are the most suitable: fuzzy logic methods, artificial neural networks, genetic algorithms, cognitive methods. Let's consider the possibilities of using AI in relation to the stages of scientific and technological forecasting (Fig.2).

Let's give a brief description of artificial intelligence technologies that can be used in the formation of forecasts for the development of science, techniques and technologies.

Semantic analysis of big data. The identification of scientific and technological trends in promising technological areas by AI methods is implemented on the basis of semantic analysis of big data (more than 400 million full-text documents) in the big data mining system iFORA and Textapplicance [16], developed by the HSE. It allows you to identify trends in the development of science, techniques and technologies, to build patent landscapes in various scientific and technological areas of development, to determine future competencies for carrying out new technologies.

The approach is used to prepare semantic and trend maps, calculate the semantic proximity of terms to each other, animate a list of words, add new terms to semantic maps and other mapping tasks in which operations related to word representations in vector space must be performed for a list of selected keywords. The selection of key terms using the animation service allows you to control in advance the approximate composition of the terminological space transmitted to the final versions of the maps.

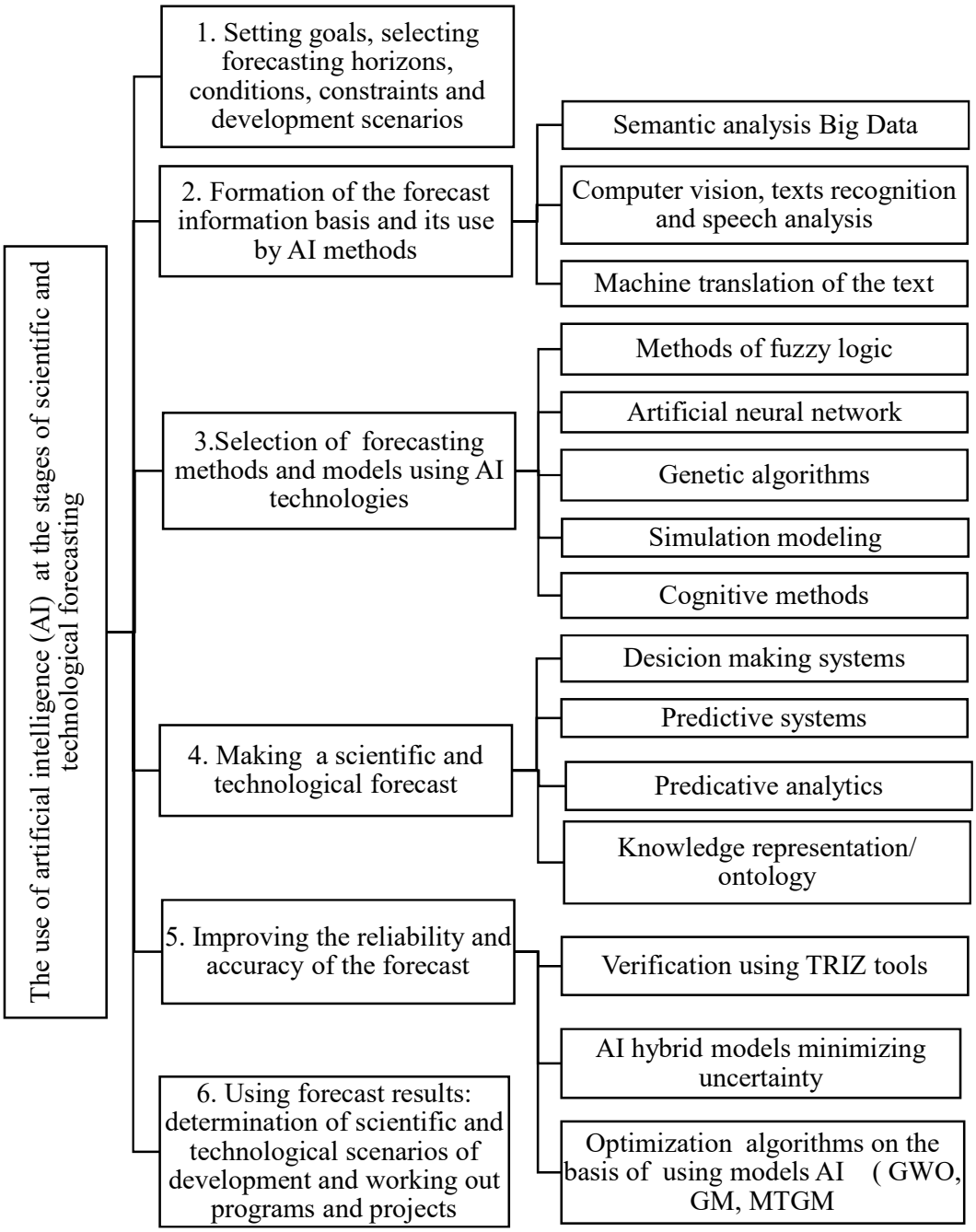

Figure 2: Structure of artificial intelligence technologies using at the stages of scientific and technological forecasting

The primary results of mapping are represented by semantic maps - compact visual representations that allow us to judge the key scientific and technological trends in the field of defense industry, covered in open scientific and media sources of information. Visually, trends are located on the semantic map in the form of dots with captions. The size of the points depends upon the degree of development of the

topics corresponding to the points in part of the analyzed directions, and the proximity between thematically close terms is shown using lines (graph edges) and corresponds to the degree of remoteness of the corresponding points from each other. The most related topics are included in the same cluster and are painted in the same color. . The semantic map is used as a basic tool for mapping and defining the boundaries of the technological landscape under study, allowing to identify common patterns of research objects and directions for further in-depth analysis. Based on semantic maps, further research is carried out according to a given scenario, including approbation and a comprehensive assessment of the results obtained. The mechanism of semantic mapping is described in detail in the authors' article [17]. As an example, Figure 3 shows a semantic map in the direction of "Artificial Intelligence".

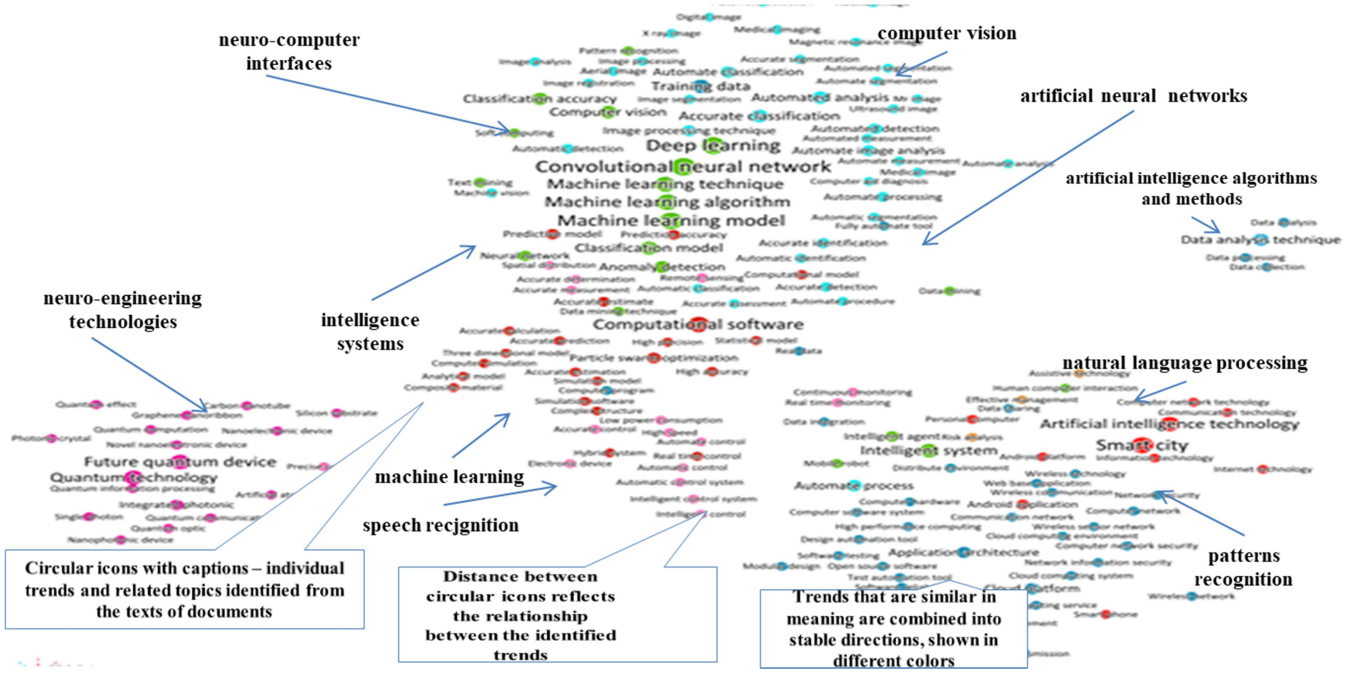

Figure 3: Semantic map in the direction of "Artificial intelligence" [16]

Semantic maps present new trends with related topics. Individual topics are indicated by color icons, the captions to which reflect the name of the trend. The most significant trends are highlighted in large font. Groups of related trends are displayed with symbols of the same color, and they form clusters according to the technological direction under study.

Among the most significant areas are machine and deep learning; natural language processing technologies; speech recognition and synthesis; facial recognition; computer vision; general artificial intelligence technologies;

neurocomputer interfaces; recommendation systems.

Trend maps allow you to distinguish four main categories (quadrants): stable directions, growing directions, "weak signals" and emerging trends (Fig. 4)

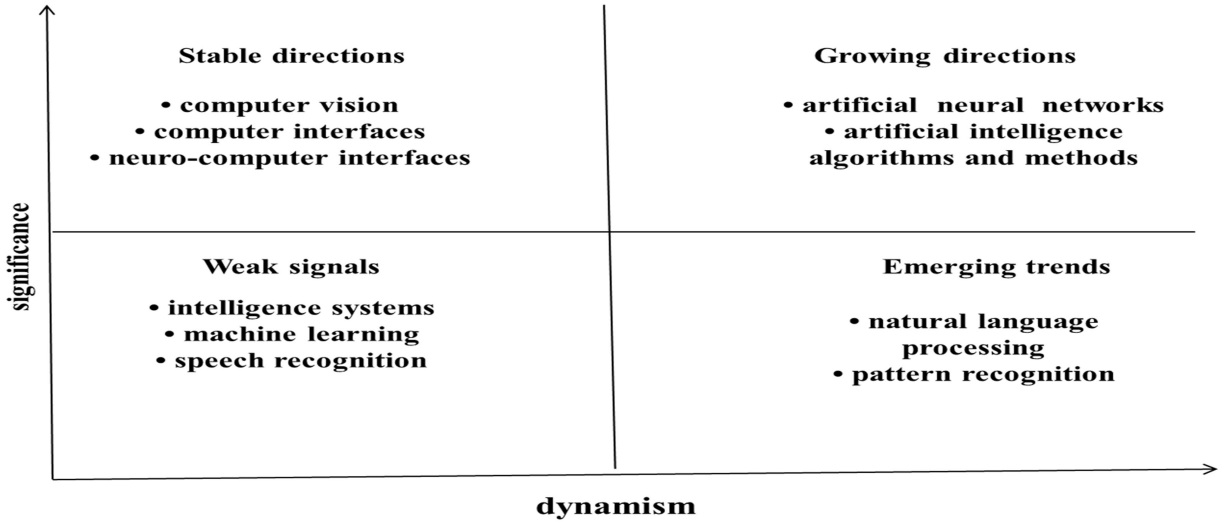

Figure 4: Trend map of the enlarged factor "Artificial Intelligence"

"Weak signals" include technologies that are only gaining popularity, as well as other topics that may receive active development in the near future.

Fuzzy logic is a classical logic combined with set theory. It uses the concept of a fuzzy set. This is an object with the function of an element belonging to a set, which takes values in the range [0, 1] in the conditions of information fuzziness.

Such e Fuzzy logic methods have been actively used in control tasks, recognition systems, data processing, decision-making, etc. [18].

Most cases of decision-making in the real world take place in a situation in which the source data is not exactly known. Therefore, when solving practical problems, they try to use fuzzy data to more accurately describe situations in decision-making methods.

Artificial neural networks. Artificial neural networks (ANN) are computational systems that are based on the principles of biological neural networks. Artificial neuron is a function that converts several input facts into one output, i.e. the ANN allows you to model a certain nonlinear function with input and output data.

The activation function of a neuron is the calculation of the output signal of a non-neuron provided that the input of this

function is the sum of all the products of signals and the weights of these signals.

With the help of the ANN it's possible to classify images, recognize handwritten numbers, represent words in vector space, predict time which can be used in the formation of scientific and technological forecasts rows [20].

The synthesis of expert methods with neuro-fuzzy networks is of interest. An example of a neuro-fuzzy element with the reverse propagation of the error from the leaves to the root of the tree (ANFIS-network) is shown in figure 5.

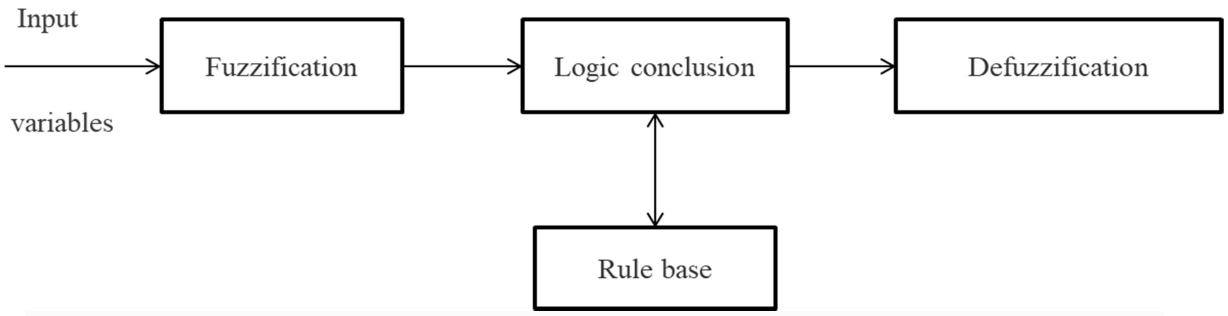

Figure 5: ANFIS-network structure

Such networks can be applied for classification complex objects in a multidimentional weakly formalized simple, necessary for predicting the development of space [21].

Genetic algorithms are the method of intelligence data analysis with using mechanisms similar to the ones of natural selection in the nature. They are often used in combination with fuzzy systems to present and management of all kinds of data. Genetic algorithms and methods of evolutional programming taken from biology provide the most effective means for scientific and technological projecting [22].

Fuzzy systems provide an unusually rich way to represent and process a wide range of diverse business industrial and technical data. Clustering systems based on fuzzy logic, queries and rules have a richness and breadth of representation that is difficult, if not impossible, to achieve with the help of appropriate technologies based on clear or Boolen logic. Genetic algorithms and evolutionary programming systems not only provide powerful and adaptive methods for generating and configuring fuzzy systems (searching for the best cluster centers and studying multidimensional data using methods such as genetically evolved regression analysis), but form the basis for a new generation of

reliable, flexible and easy-to-use optimization models.

The essence of cognitive methods is the analysis and management of factors that affect the process of perception and interpretation of certain circumstances by a person forming a picture of the current situation in his mind. E.g., black and white photography is comprehended by a man as more documentary and significant than colored one. I.e. the color of photo is a cognitive factor that influences the information meaning. Cognitive methods are used effectively in monitoring scientific and technical achievements as well as revealing new breakthrough technologies and modern technical decisions [24]. The method of exchanging expert knowledge about the dynamic properties of situations (causal relationships) and their fixation in the form of a so called cognitive map is widely used [2] (fig.6).

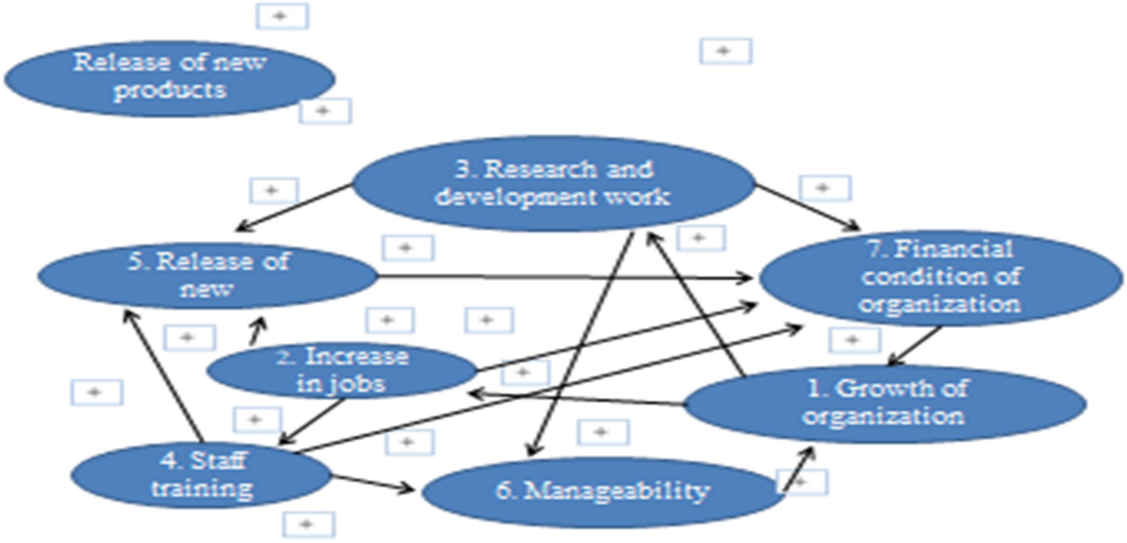

Figure 6: Cognitive map for predicting the release of new products

Such structuring makes it possible to more clearly define the nature and strength of the interaction of factor variables in the cognitive model. It will help to assess and predict the future changes, give appropriate recommendations to scientific enterprises in such key fields as industry, military armament and special technique, space systems, aviation, energy, etc. [26].

Information and analytical support for the use of AI in scientific and technological forecasting. Decision support information technologies represent a whole class of software systems designed to facilitate the work of analysts. Such systems are called decision support system (DSS) (Fig.7).

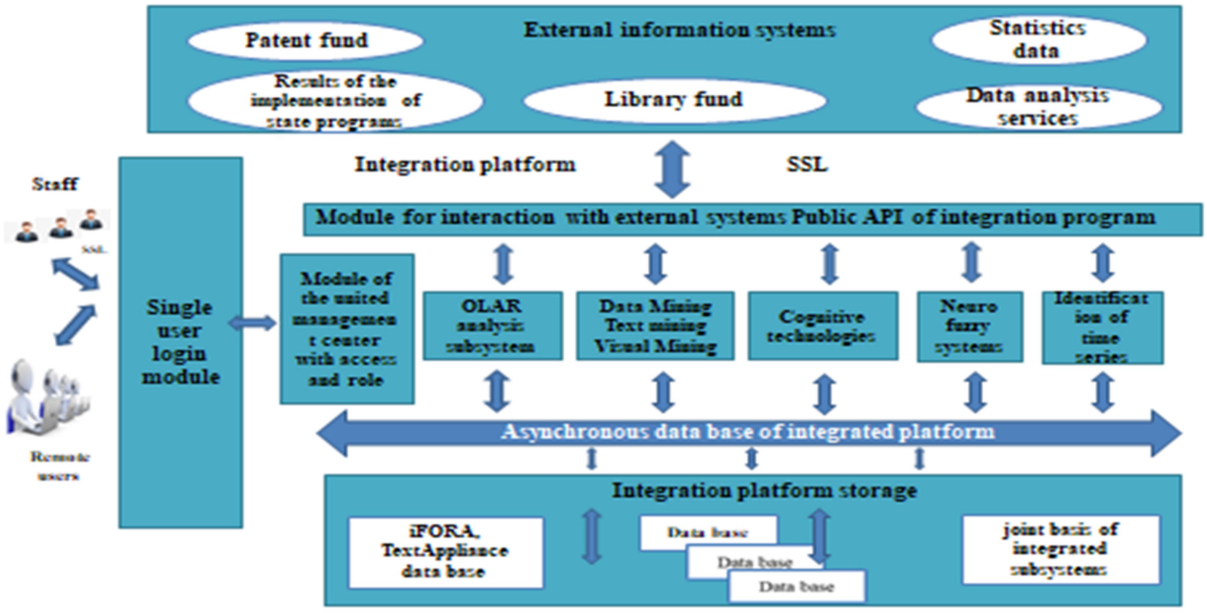

Figure 7: Decision making support system ion the basis of AI use

The structure of this system includes:

On-line analytical processing subsystem (OLAR) that uses multidimensional data representation ;

On-line intelligence analysis subsystem of Data Mining;

On-line unstructured text analysis subsystem Text Mining;

On-line visual data analysis subsystem Visual Mining;

On-line subsystem of cognitive maps building;

Neural fuzzy systems for organizing neural network data analysis.

Decision support systems often use time series forecasting, so the accuracy od such systems is of great importance for their effectiveness. Since most systems currently require processing large amount of data automatic identification of time series models has become necessary. AI solves successfully this task.

Creation of information support system for predictive research in the interest of defense and security in terms of areas of fundamental and exploratory scientific research and a decision support system will bring the forecasting of the results of fundamental scientific and research to a new level , improve the quality and reliability of forecasts, as well as significantly reduce the resources used to ensure the processes of forming forecasts.

CONCLUSIONS

As a result of a study the authors proves the hypothesis that the use of AI technologies forecasting will significantly

speed up the process of forming a forecast, improve its quality and reliability, as well as reduce the financial and material costs of conducting technical forecasting.

The most suitable methods of AI for using when forming forecast for science, techniques and technologies are the following: semantic analysis trend detection analysis of science, techniques and technologies development on the basis of big data base using, methods of fuzzy logics, artificial neural networks, genetic algorithms, cognitive methods. Decision making systems, predictive systems, predicative analytics can be used to forming scientific and technological forecast. It's effective to use ontological concept of cards for the unity of terminology. To improve reliability and accuracy of the forecasting AI hybrid models can be used for the unity of terminology. It will minimize the uncertainties, optimization algorithms on the basis of AI models using as well as forecasting results verification with using tools of decision theory of invention tasks [28].

The significance of the study conducted by the authors is that presented scientific and methodical practical recommendations on AI using technologies for science, techniques and technologies development forecast forming will allow to organizers and participants of scientific and technological forecast forming to start work on AI application in this process that will reduce the terms and increase the quality of scientific and technological development forecast forming in Russia.

The studies conducted were restricted by development of common and conceptual problems of AI technologies use when scientific and technological forecasting. Methodology for identifying the main trends in the development of science and technology based on semantic big data analysis was shown in the most detail. Other AI technologies that can be used when forming a forecast of science, techniques and technologies development are shown in general form and links to sources are provided, where the possibility of theior use in forecasting is disclosed in more detail.

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