REVIEW

Robotics by multimodal self-organizing ensembles of software and hardware agents with artificial intelligence

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Received: March 16, 2024;
Accepted: May 16, 2024;
Published: May 20, 2024.

Citation: Bryndin E. Robotics by multimodal self-organizing ensembles of software and hardware agents with artificial intelligence. *Res Intell Manuf Assem*, 2024, **2**(1): 60-69.
https://doi.org/10.25082/RIMA.2023.01.003

Abstract: Self-organizing ensembles of software and hardware agents with artificial intelligence model the intellectual abilities of a person's natural intelligence. The Creator endowed man with various types of intellectual abilities: generation of meanings, perception of meanings, meaningful actions and behavior, sensory reaction to meanings, emotional reaction to meanings. Based on the synergy of various intellectual abilities, a person carries out life activities. For example, Dialogue is conducted on the basis of two intellectual abilities: the generation and perception of meanings. A multimodal self-organizing ensemble of intelligent software and hardware agents with artificial intelligence, based on existing knowledge and skills, is able to write poetry, draw pictures, give recommendations and solutions to specialists, manage production and systems in various sectors of the economy, and take part in scientific research. Multimodal ensembles of intelligent agents, modeling the functions of natural intelligence, contain a functional control structure. To ensure the safe and reliable use of multimodal ensembles of intelligent agents, they are being standardized internationally under the guidance of ISO. International standardization of multimodal ensembles of intelligent agents expands the market and reduces the risks of their use.

Keywords: multimodal self-organizing ensembles, software and hardware agents, artificial intelligence

1 Introduction

Axioms, rules, principles and criteria for the functioning of artificial intelligence are determined by natural intelligence. Natural intelligence also makes sense of and interprets the results of artificial intelligence. Artificial intelligence is under the control of natural intelligence.

Artificial intelligence models the cognitive thinking and psychophysical skills of natural intelligence [1, 2]. Cognitive thinking is modeled at the symbolic and figurative virtual level. Psychophysical skill is modeled at the virtual and real levels.

The most important AI trend in 2024 will be the emergence of multimodal search/retrieval architectures and multimodal inference, which will take center stage in AI products, predicts Rak Garg, director at Bain Capital Ventures. The next frontier for artificial intelligence models, all signs point to multimodal systems where users can interact in multiple ways. Multimodal self-organizing ensembles of software hardware agents with artificial intelligence are closer to the human mind compared to other intelligent systems. OpenAI is making rapid progress. The company is actively hiring experts in multimodal transport. The company is working on a new project called Gobi, which is expected to be a multimodal cognitive adaptive system with artificial intelligence. The multimodal system will manipulate images, sounds and videos, as well as text. Such a system will help create multidisciplinary robots. This requires a specialized set of advanced search tools for multimodality innovation.

Florence, an intelligent multimodal system developed by Microsoft, models space, time and modality of events. The multi-modal architecture of Adept Fuyu-Heavy is designed to create intelligent digital agents for various uses. Adept Fuyu-Heavy understands complex user interface queries. According to experts, it is superior to existing multimodal reasoning.

In April 2024, Russian researchers introduced a new multimodal artificial intelligence model called OmniFusion. This is a significant development in the world of technology, as the model is capable of working with various types of data, including text and images. OmniFusion 1.1

architecture allows not only to analyze images, but also to interact with the user through a visual dialogue. The model is capable of performing various tasks, ranging from recognizing objects in photographs to solving mathematical examples. It can also be trained to analyze medical images, opening up new prospects for healthcare applications. Most importantly, the code of the original model has become available to the public, which contributes to the further development and application of AI technologies in various fields.

Ensembles of software and hardware intelligent agents imitate the abilities of natural human intelligence in virtual and real space. Robotic ensembles, like human counterparts with artificial intelligence, can reproduce most virtual processes and human skills in the real world. Ensembles of software and hardware intelligent agents are trained to create texts, but they cannot themselves identify new meanings and create theories. So far, experts have not been able to create ensembles of software and hardware intelligent agents capable of consciously and emotionally reacting to various jokes. Multimodal ensembles of intelligent agents with artificial intelligence can carry out tasks of specialists [3].

Artificial intelligence researchers are striving to build a universal theory for modeling natural intelligence by multimodal self-organizing systems. The author suggested multi-purpose hierarchical multi-layer approach to creating multimodal ensembles of software and hardware intelligent agents.

2 Multi-purpose hierarchical multi-layer approach to creating multimodal intelligent systems

A section of the article is devoted to consideration of the hierarchical structure, multi-purpose organization, multi-layer decision making and self-organizing control of multimodal intelligent systems.

2.1 Complex hierarchical multi-purpose structure of the organization of a multimodal intelligent system

The complex hierarchical structure of the organization of a multimodal intelligent system provides for a combination of centralized control with autonomy of parts (subsystems) with self-regulation and adaptation. At its core, a hierarchical organizational structure consists of multi-layered management and three levels of authority. The lower level is responsible for physical operations, the middle level for psychological actions, and the upper level for cognitive functions. Physical operations are carried out by robotic systems and digital twins [4, 5]. Psychological actions are implemented by bioinformation systems [6]. Cognitive functions are performed by ensembles of intelligent agents [7].

Centralized and leveled control facilitates more thorough monitoring of the activity of a multimodal intelligent system, which ensures high-quality control. The hierarchical multimodal intelligent system is functionally efficient, providing a balance between control and flexibility. Thoughtful implementation of hierarchy maintains clarity, specialization and coordination among all levels and horizontal roles, while ensuring security, autonomy, multi-level communication and execution control. For each level there are characteristic features, laws and principles with the help of which the behavior of the system at this level is described. The hierarchy of an intelligent system is defined by a family of models, each of which describes the behavior of the system from the point of view of the corresponding level.

The family of models includes a theoretical-cognitive description of its concept, a design representation of the system, design, technology, and software and hardware functional implementation. The lower we go down the hierarchy of levels, the more detailed the disclosure of the system becomes; the higher we rise, the clearer the meaning and significance of the entire system becomes. It is almost impossible to explain the purpose of the system using lower-level elements in complex intelligent systems. The idea must not be distorted when revealed at each subsequent level.

One of the main stages in developing an effective organization of a system is the formation of a structure based on the analysis and synthesis of subsystems. This analysis and synthesis of the subsystems under consideration involves bringing the structure of the organization into line with its goals, objectives and requirements. Analysis and synthesis of structures is carried out in the following stages to determine: a formalized description of the functioning of the elements of the structure; the goals of each of the structure elements; corrective changes in the structure.

Changing goals in the structure should be based on the following principles: simultaneous achievement of the goal; the sequential method, when goals are achieved sequentially over time; placement of goals depending on the prevailing circumstances; the principle of hierarchy of alternative methods of action and defining characteristics; the principle of reduction in the transition from complex to simple; the principle of specification (using only information specified explicitly when solving a problem).

2.2 Multilayer structuring of the organization of decision-making processes

Multilayer structuring is introduced to organize decision-making processes. To reduce the uncertainty of the situation, levels of complexity of the decision being made are distinguished - layers, i.e. a set of sequentially solved problems is determined. In this case, problems are identified in such a way that the solution to the underlying one would determine the limitations (permissible degree of simplification) when modeling at the underlying level, i.e. would reduce the uncertainty of the underlying problem, but without losing the intent of solving the overall problem. To do this, a top-down flow of directives is created: Strategies and directives are created at the top of the hierarchy and propagated to subsequent levels below. This facilitates agreement on common goals. Vertical communication channels are created. Information typically moves up and down different levels of the hierarchy, with limited switching between disparate subsystems. The organizational pyramid supports horizontal communication. Hierarchy ensures clear governance and avoids confusion about who has decision-making authority. Specific roles allow for the use of specialized skills and prevent duplication of effort.

Let's consider a multi-layered hierarchy of decision-making for managing any process. In it, under conditions of uncertainty, three main aspects of the decision-making problem can be distinguished. The bottom layer, the "closest" to the controlled process, is the selection layer. The task of this layer is to choose a method of action m. The decision-making element (block) receives data (information) about the controlled process and, using the algorithm obtained in the upper layers, finds the desired method of action, i.e. sequence of control actions on the controlled process. The algorithm can be defined directly as a functional mapping D that gives a solution for any set of initial data. Suppose that an output function P and an evaluation function G are given, and the choice of actions $\{m\}$ is based on the application of an evaluation of G to P.

Using set-theoretic representations, the output function can be defined as a mapping $P:M\times U\rightarrow Y$, where M is the set of alternative actions; Y is the set of possible outputs (or "outputs"); U is a set of uncertainties that adequately reflects the lack of knowledge about the relationship between action and output Y. Similarly, the evaluation function G is a mapping $G:M\times Y\rightarrow V$, where V is a set of quantities that can be associated with the characteristics of the quality of the system. If the set U consists of a single element or is empty, i.e. there is no uncertainty regarding the output result for a given action m, the choice can be based on optimization: find such m' in M such that the value $v'=G(m',P(m'))$ is less than $v=G(m,P(m))$ for any other action $m\in M$. If U is a richer set, we have to propose some other procedures for choosing a solution method. In this case, it will be necessary to introduce some other mappings, in addition to P and G. But in the general case, in order to determine the selection problem on the first layer, it is necessary to clarify the set of uncertainties U, the required relations P, G, etc. This is done on the upper layers.

The layer of learning or adaptation that lies above the layer in question. The task of this layer is to specify the set of uncertainties U, which the selection layer deals with. The set of uncertainties U is considered here as a set that includes all ignorance about the behavior of the system and reflects all hypotheses about the possible sources and types of such uncertainties. The set U can be obtained using observations and external sources of information. The purpose of the layer under consideration is to narrow the set of uncertainties U and thus simplify the selection layer model. In the case of stationarity of the system and environment, U can be extremely narrowed down to one element, which corresponds to ideal learning. However, in the general case, U can include not only existing, but also uncertainties assumed by the decision-making system, and if necessary, U can be completely changed and expanded, including by changing the previously accepted basic hypothesis.

The third, in this case the top layer of self-organization. At this layer, the structure, functions and strategies used in the underlying layers are selected in such a way as to get as close as possible to the display of the goal, which is usually given in the form of a verbal description. If the goal is not achieved, the P and G functions in the first layer or the learning strategy in the second can be changed.

It is useful to form multilayer decision-making systems to solve problems of planning and management of industrial enterprises, industries, and the national economy as a whole. When formulating and solving such problems, it is impossible to define goals once and for all and choose specific actions: the economic and technological conditions of production are constantly changing. All this can be reflected in a multi-layer decision-making model. The system is represented in the form of relatively independent subsystems interacting with each other; Moreover, some (or all) subsystems have decision-making rights, and the hierarchical arrangement of subsystems (multilayer structure) is determined by the fact that some of them are influenced or controlled by their superiors.

The main distinctive feature of a multilayer structure is the provision of subsystems at all levels with a certain freedom in choosing their own solutions; Moreover, these decisions may (but do not necessarily) differ from those that would be chosen by a higher level. Providing freedom of action in decision-making to components of all layers of the hierarchical structure increases the efficiency of its functioning. Subsystems are given a certain freedom in choosing goals. Therefore, multilayer structures are multi-purpose. In such systems, different decision-making methods can be used. Which is one of the conditions for increasing the efficiency of the system.

2.3 Intelligent self-organizing ensemble of software and hardware agents for multimodal management

The possibilities for the practical development and application of artificial intelligence in the social sphere and industry depend on the systemic self-organization of an ensemble of software and hardware agents for management. An intelligent self-organizing ensemble of software and hardware agents for management contains systems for analysis, forecasting, planning, organizing, coordinating, optimizing and monitoring security. Analysis and forecasting are part of planning. For reliable analysis and forecast, the ensemble uses artificial intelligence methods and data that are associated with the control object. The planning system replaces the functionality of the customer's management process, composed of acts, with a sequence of operations from the skill base, and presents the totality of all operations in the form of a visual diagram. Organizational management is carried out on the basis of visual diagrams of operations. The control system allows you to track the execution and safety of management. The control system's control operation monitor tracks the execution of each operation and audits the control history. The optimization system activates the management modeling process, assesses risks and improves the management plan based on the activity monitor audit. An intelligent multimodal self-organizing ensemble of software and hardware agents moves on to multimodal manage practical activities based on existing AI technologies and tools.

3 On the international standardization of safe artificial intelligence systems

For the safe use of artificial intelligece systems in the social, industrial and scientific spheres, international standardization is being carried out. Safety for artificial intelligence and ethical codes on the use of intellectual systems are developed in a wide format of directions by specialists of various companies by different countries at the international level.

Since 2021, the Code of Ethics of Artificial Intelligence has been operating in Russia. The code establishes the general ethical principles and standards of behavior that should be guided by participants in relations in the field of artificial intelligence in their activities. Russian experts have developed standards that regulate the safety of artificial intelligence systems not only for people, but also for the environment. Standardization concerns the introduction of artificial intelligence in various fields of human activity, such as transport, medicine, education, construction and a number of others. On September 30, 2023, the Russian Association, the House of Indo-Russian Technological Cooperation (Chamber for Russian Technology Collaboration, Cirtc) and the Russian Technical Committee No. 164 of the Rosstandart of the Russian Federation signed two memorandum of cooperation intentions aimed at developing relations between Russia And India in IT oblast. One of the documents concerns the standardization of artificial intelligence, as well as the creation of a joint laboratory for certification of solutions in the field of artificial intelligence. Interaction in the standardization of artificial intelligence will apply to the participants of the BRICS+. What will help to develop and apply the standards common to the BRICS countries. The Minister of Information Technology of India Rajiv Chandrakar proposed to develop a global security standard for artificial intelligence so that intellectual systems do not harm a person and social, industrial and natural environment.

In 2023, the United States, Great Britain and more than ten other countries announced the signing of an international agreement on how to protect artificial intelligence systems. The document involves the creation of AI platforms designed in such a way that they are safe from the very beginning of their development.

In 2023, representatives of 28 individual countries, including the USA, EU, Canada, China, Singapore, Japan, South Korea, Israel, India and the United Arab Emirates signed an international declaration for the safe use of artificial intelligence.

The Japanese Technical Committee for Standardization of Artificial Intelligence has approved the international standard: A.111 Application of strong artificial intelligence - "ISO/IEC JTC 1/SC 42/WG 4 No 254 TR 24030", developed by the Research Center Natural Informatics, Novosibirsk, Russia.The standard case for the use of strong artificial intelligence contains generalized options. The standardization of the use of strong artificial intelligence ends with the developer by a specification of generalized options for each targeted use. The standard case contributes to the use of strong artificial intelligence in promising modern areas, such as: multi modal generative artificial intelligence, cooperation of intellectual digital doubles and humans, ethical artificial intelligence, quantum artificial intelligence, legitimization of artificial intelligence, intellectual chabitization, semantic emotional dialogue, and so on [7–10].

In 2024, experts in the field of education and artificial intelligence of various countries develop international ethical standards for the use of intellectual systems for training. The standards of Japan provide for the use of generative tools of artificial intelligence in schools, from elementary grades to high school. On February 14, 2024, the National Research Institute for the Study of Generative Artificial Intelligence began to function in Japan. Japan began testing artificial intelligence systems in primary, junior and high schools. Japanese private companies have created several systems with artificial intelligence for Japanese schools. The Konica Minolta system is able to analyze students' reaction to the material presented, can collect data on the level of concentration of students, and activity in the rise of the hands. The system from Techno Horizon is designed to analyze the emotional state of each of the students. The artificial system helps to identify which children are excited, which children are in a state of stress or bored and concentrated children. Intellectual systems monitor the performance and effectiveness of the education of schoolchildren, give recommendations to teachers in the learning process.

4 Application of multimodal intelligent systems

4.1 Business analytics

One of the problems of business analysis is obtaining and processing an ever-increasing volume of data of economic, financial, organizational and political-legal content. Multimodal business analytics introduces a new methodology that combines classical business analysis with big data technologies, intelligent business analytics, multimodal data fusion, artificial neural networks and deep machine learning. Expanding the functionality of business analysis through the use of methods and tools of multimodal business analytics makes it possible to obtain systematic assessments of various aspects and results of enterprise activities, as well as to predict their development. The use of IBA methods and tools allows you to obtain new information and form more accurate comprehensive assessments in such types of analysis as industry, market and competitive; analysis of the organizational management structure, corporate culture and human resources of companies; analysis of business processes and information structure of companies; analysis of the results of financial and economic activities and the production and economic potential of companies, etc [11–13].

4.2 Logistics

The development of multimodal intelligent systems is an important step in improving the efficiency of logistics processes. One of the key aspects in the field of transportation is the choice of optimal transport for cargo delivery. Thanks to the use of modern technologies and innovative solutions, multimodality allows you to combine different types of transport, providing a high degree of flexibility and convenience in the delivery of goods. Integration of various modes of transport into multimodal systems allows optimizing logistics processes, reducing delivery time and improving the quality of services. Combining different modes of transport, such as road, rail, sea and air, allows you to effectively use their advantages and minimize their disadvantages.

The introduction of multimodal systems is becoming increasingly relevant in the modern world, where transport flows are constantly increasing. These systems solve many problems related to the organization and optimization of logistics processes, ensuring uninterrupted transportation and improving the quality of services. Thanks to the implementation of multimodal systems, organizations can achieve significant economic effects and increase their competitiveness in the market.

Multimodal systems are an important tool for optimizing logistics processes. They allow you to effectively combine different types of transport, providing convenience and a high degree of flexibility in the delivery of goods. The integration of modern technologies and innovative solutions can significantly improve transportation efficiency and ensure uninterrupted logistics processes. The introduction of multimodal systems makes it possible to achieve economic effects and increase competitiveness in the market.

4.3 Education

In modern education, more and more attention is paid to multimodal learning. This is a new approach based on the use of multiple modalities - visual, auditory and kinesthetic - to deliver information and stimulate the learning process. Multimodal learning allows you to create more effective and interactive lessons that promote deep understanding and active student participation. One of the main reasons for the growing popularity of multimodal learning is its ability to address different types of intellectual preferences of students. Some people remember information better if they see it visually (visual modality), others prefer to hear it (auditory modality), and some remember it better through physical interaction (kinesthetic modality). Using all three modalities at the same time allows each student to choose the most effective way to assimilate information.

Another benefit of multimodal learning is its ability to make lessons more interesting and engaging for students. Instead of a traditional lecture, which can be boring and monotonous, multimodal learning offers a variety of activities that include the use of video, audio, graphics and physical movement. This helps students stay interested and actively participate in the learning process. The core principle of multimodal learning is to create a rich teaching environment that will stimulate all of the students' senses. This is achieved by combining different techniques, such as lectures with presentations, video lessons with interactive tasks, or even role-playing games. An important aspect of multimodal learning is the active involvement of students in the learning process. They must be able to independently examine materials, conduct experiments, or solve problems based on their knowledge. This helps not only to consolidate theoretical material, but also develops critical thinking and creative abilities.

Multimodal learning methods may include the use of technologies such as virtual reality or augmented reality. They allow you to create interactive environments where students can interact with objects and phenomena of the material being studied. This makes the learning process more fun and memorable. Another method of multimodal learning is the use of different types of materials: text, audio and video materials, graphs and diagrams. Each provides information in a different form to help make it more understandable and accessible to different types of learners. Multimodal learning is a teaching strategy that uses a variety of media and learning tools to instruct and educate students, typically through a learning management system (LMS). When using a multimodal learning system, it is not just words on a page or the voice of a teacher giving a lecture, but instead these elements are combined with videos, pictures, audio files and hands-on exercises to give the student the best learning opportunity. E-learning platforms cover theoretical and practical capabilities to provide them to educational service providers. When students know about something and begin to do it as they learn, their performance levels increase and they are more likely to master the knowledge content. This approach allows students to absorb information more effectively and develop different skills at the same time.

4.4 Medicine

Healthcare organizations are using multimodal intelligent systems to improve the quality of patient care by obtaining information from multiple modalities, including patient histories, images, medical records and other data. Modal intelligent systems improve physician decision making and experience through hybrid information integration.

The use of biomedical signals in the implementation of intelligent multimodal interfaces is beginning. Information characteristics of biomedical signals modulated by the functional processes of the body can be used in applications that require obtaining data on the psychophysical state of a person and making a quantitative assessment of changes in a person's state. The development of intelligent multimodal interfaces begins with brain-computer interfaces. The EEG signal and data from a 3-axis accelerometer placed on the human head are used as input modalities of the interface. The architecture of multimodal interfaces is associated with the use of signal processing methods and machine learning methods to generate metrics of changes in a person's functional state, as well as for data storage.

5 Examples of using multimodal robotic ensembles

Standardization of intelligent systems helps to securely use them in many industries and services. Intelligent robots are used in various countries as librarians, hotel administrators, tour guides, salespeople, lecturers and other social service providers. Intelligent multimodal robot with technological thinking and spectroscopic vision (Figure 1), multimodal humanoid communication robots can work in many areas of activity and serve many clients (Figure 2), Chine library robot (Figure 3) and Indian library robot (Figure 4) and American intellectual library system for issuing books (Figure 5) serve visitors and fulfill their orders, Russian library robot guide (Figure 6) introduces visitors to paintings by various artists, Japanese robot-administrator of hotel Henn-na Hotel (Figure 7) checks visitors into rooms by number, Japanese robot lecturer (Figure 8) teaches students, European smart cleaning robots (Figure 9) picks up trash on the street,Iranian intelligent communication robot Surena 4 (Figure 10) recognizes and tracks faces and objects, generates full body movements, and recognizes and synthesizes speech and dialogue, Korean multimodal robot analytic (Figure 11) audits business companies, German aerial unmanned taxi (Figure 12) transports passengers along the air corridor, Singapore robot waiter (Figure 13) humanoid robot Pepper takes orders and processes accounts for Pizza Hut customers in Singapore using the global electronic payment service MasterPass, Russian car without a driver (Figure 14) transports passengers along a given route, multimodal generative intelligent robot (Figure 15) communicates cognitively with people and conducts dialogue.

Figure 1 Intelligent robot with tech thinking and spectroscopic vision

Figure 2 Human-Robot communication

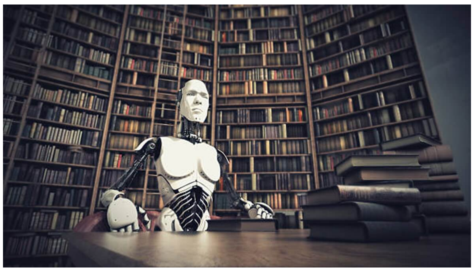

Figure 3 Chine library robot

Figure 4 Indian library robot

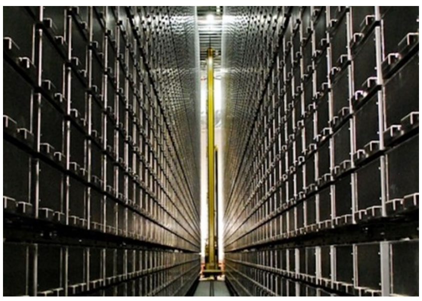

Figure 5 American intellectual library system for issuing books

Figure 6 Russian library robot guide

Figure 7 Japanese robot-administrator of hotel Henn-na Hotel

Figure 8 Japanese robot lecturer on literature

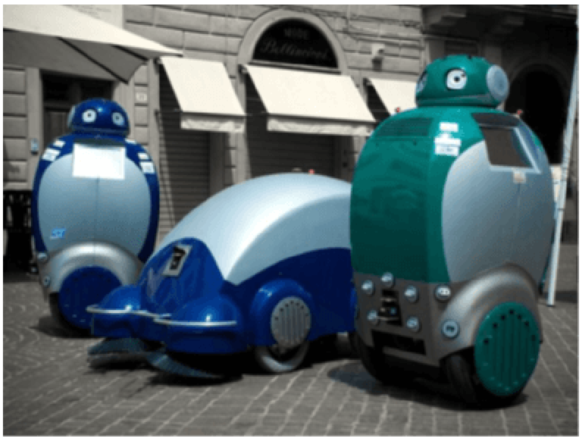

Figure 9 European smart cleaning robots

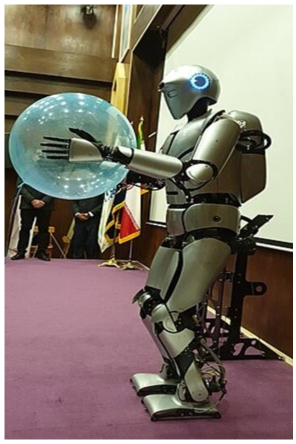

Figure 10 Iranian intelligent communication robot Surena 4

Figure 11 Korean multimodal robot analytic

Figure 12 German aerial unmanned taxi

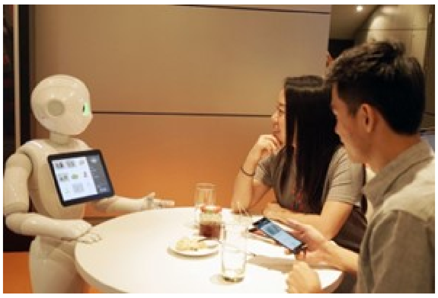

Figure 13 Singapore robot waiter

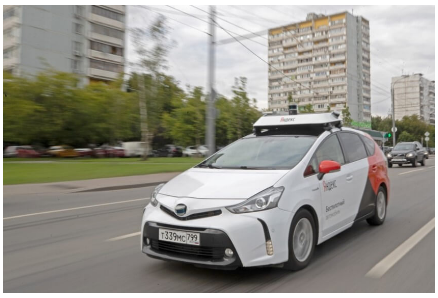

Figure 14 Russian car without a driver

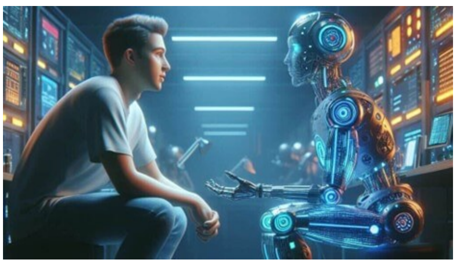

Figure 15 Multimodal generative intelligent robot

6 Conclusion

Currently, multi -modal generative technologies of artificial intelligence continue to effectively transform various industries. Generative artificial intelligence is constantly improving and approaching in cognitive abilities to natural intelligence. Artificial intelligence builds activity on the basis of a productive system of rational and moral meanings approved by the practice. Productive meanings are active memory elements. Based on them, thinking is built in actualized situations and circumstances. Thinking is carried out on the basis of knowledge of holographic memory, taking into account the time and space of current events based on searching for patterns. The process of cognitive search for patterns consists of two modalities. Cognitive analysis of experimental data and identification of patterns using forecasting methods based on the results of the analysis.

The cognitive analysis of data uses mathematical methods and algorithms, the systems of data processing and technology of visual representation of data. Cognitive methods of the analysis of data: statistical methods, methods of computer mathematics, optimizing methods, expert methods, synergetic methods, methods of indistinct sets, methods of fractal mathematics, methods of conflict situations. Algorithmic systems of data processing: subject-oriented analytical systems, the systems of the statistical analysis, the trained neural networks, associations on analogies, trees of decisions, evolutionary programming, algorithms of search, the system of visualization of multidimensional data.

Methods of the forecast of situations: the determined forecast, the statistical forecast, a method of program forecasting, a method of heuristic forecasting, temporary ranks, extrapolation method, expert method, the forecast on the basis of linear regression, the interpreted method, the case analysis, the synergetic analysis, the evolutionary statistical forecast. The tasks solved by cognitive methods of the analysis of data: detection and assessment of the hidden regularities, detection and assessment of influence of the hidden factors, assessment of the current situation, the forecast of development of the situation, formation and optimization of the operating decisions. The cognitive machine technology helps to take new regularities effectively. Engineers and programmers create cognitive methods of structuring and classification of Smart Big Data for identification of regularities by logical format.

The cognitive robots with communicative and associative logic of thinking having the systems of machine retraining will be able quickly to change professional qualification and competences. The international scientific and engineering society gradually moves to technical realization of the cognitive professional robot with retraining. In the future in labor market cognitive robots with retraining will perform professional works, and the person will occupy a niche of scientific research of creative innovative activity.

To create a creatively capable artificial intelligence similar to natural intelligence, it is necessary to create a full-fledged virtual environment in which the standards will be by norms of creativity and creation [14–25].

When researchers are able to carry out in the Smart format universal standardization of the safety of knowledge and skills of multimodal hierarchically functional interdisciplinary artificial intelligence, then digital twins and robots with spectral vision and bioinformational holographic memory will become indispensable assistants in industry and in other fields of activity and will be a full complement to natural human intelligence.

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