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INTELLIGENT ROBOTS ON MARS: THE FIRST STEP TOWARDS THE COLONIZATION OF THE RED PLANET

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Анотація. *У статті розглядаються високоінтелектуальні людиноподібні роботи та їхні переваги при підготовці до колонізації Марса. Описуються переваги використання роботів, такі як зниження вартості місії, тому що їм не потрібне обладнання для захисту від космічної радіації, різних температур та інших небезпек, що робить їх ідеальними не лише для перельоту, а й для проведення робіт у непридатному для людини середовищі Марса. Відсутність необхідності в ресурсах для життєдіяльності, оскільки передача ресурсів із Землі на Марс вимагає великих витрат енергії, часу і коштів. Тривалий час роботи і підвищення безпеки в екстремальних умовах Марса, оскільки, працюючи на сонячних батареях, можуть забезпечувати себе енергією і працювати протягом тривалого часу без постійного поповнення енергоресурсів. У зв'язку з цим вони можуть працювати на Марсі набагато довше, забезпечувати постійну активність і безперервно передавати інформацію на Землю. Обговорюються можливості використання роботів для будівництва інфраструктури марсіанської бази і розглядаються сучасні розробки гуманоїдних роботів, таких як Atlas, Valkyrie і Оптимус. При цьому звертається увага на важливу перешкоду у використанні цих роботів, що виражається у відсутності у них інтелекту, який можна порівняти з людським, і пропонується рішення у вигляді застосування нової технології – багатовимірних багатозв'язкових рецепторно-ефекторних нейроподібних зростаючих мереж для створення штучного мозку. Обговорюються місії роботів-марсоходів і перспективи експедиції інтелектуальних людиноподібних роботів на Марс. Загалом стаття проливає світло на значущість і переваги використання роботів у майбутній колонізації Марса.*

Ключові слова: *роботи, колонізація Марса, штучний інтелект, багатовимірні нейроподібні зростаючі мережі, штучний мозок.*

Abstract. *The article discusses highly intelligent humanoid robots and their advantages in preparation for colonizing Mars. It describes the advantages of using robots, such as reducing the cost of the mission, since they do not need equipment to protect them from cosmic radiation, different temperatures, and other hazards, making them perfect not only for flight but also for work in the uninhabitable environment of Mars. No need for life-sustaining resources, as transferring resources from Earth to Mars is energy-, time-, and cost-intensive. Long operating time and increased safety in the extreme conditions of Mars, because working on solar panels, can provide themselves with energy and work for a long time without constant replenishment of energy resources. As such, they can operate on Mars for much longer periods of time, providing constant activity and continuously relaying information back to Earth. The possibilities of using robots to build the infrastructure of a Martian base are discussed and current developments of humanoid robots such as Atlas, Valkyrie, and Optimus are reviewed. At the same time, attention is drawn to an important obstacle in the use of these robots, which is expressed in their lack of intelligence comparable to human intelligence, and a solution is proposed in the form of the application of a new technology – multidimensional, multi-connected receptor-effector neural-like growing networks to create an artificial brain. The missions of robotic Mars rovers and the prospects for the expedition of intelligent humanoid robots to Mars are discussed. Overall, the paper sheds light on the significance and advantages of using robots in the future colonization of Mars.*

Keywords: *robots, colonization of Mars, artificial intelligence multidimensional neural-like growing networks, artificial brain.*

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1. Introduction

The aim of this paper is to investigate the issues of robotic expedition to Mars in order to show the necessity of developing new advanced technology of artificial brain for Android robots on the basis of the example of their use in the Mars colonization mission.

The modern era of space exploration is undergoing a remarkable development. Initially, scientific missions to space involved sending manned missions into the near-Earth orbit. However, recent decades have brought significant changes to our understanding of outer space, largely due to impressive advances in automated exploration technology. One landmark development has been the renewed focus on the Moon. NASA, through the Artemis program, plans to return to the Moon by 2024 and establish a stable base on its sur face. The next door, the planet Venus is also becoming an object of fascination. The Venera-D missions from Roscosmos and DAVINCI+ from NASA aim to explore the atmosphere and surface of Venus, expanding our understanding of the possibility of life on this planet. Mars and Jupiter have been the focus of attention for decades thanks to satellites and interplanetary probes. Missions such as Mars Rover Curiosity, Perseverance, and NASA's Juno mission are expanding our knowledge of these planets, their suitability for supporting life, and the availability of important resources.

This research not only unlocks the mysteries of space but also opens the way to a deeper understanding of Earth's place in the Universe. Thanks to them, plans are being developed for the long-term colonization and use of other planets. In this context, Elon Musk presents an ambitious plan to send humans to Mars. However, instead of directly immersing humans in a dangerous mission, an innovative solution is proposed: sending highly intelligent humanoid robots as a preliminary step. This robotic expedition could be the key to setting the stage for future colonization, ensuring safety and minimizing technical and financial risks. Thus, humanity stands on the threshold of a new era of space exploration, where every mission, every discovery, and every technological innovation expands the horizons of our understanding of the Universe.

2. Highly intelligent humanoid robots

On the way to effective and safe preparation for Mars colonization, Elon Musk plans to send a group of people there. Moreover, it will be impossible to return this group to Earth for technical reasons. The task of this group of astronauts will be to explore the possibilities, create conditions for human habitation on Mars, and build a base to welcome other settlers. The project is expensive and dangerous. But it is possible to offer an alternative option for solving this problem. First, not humans but robotic Androids should be sent to Mars. These humanoid robots can safely explore the surface of the Red Planet, prepare a site, and build a base for future settlers.

2.1. Advantages of using robots to prepare for the colonization of Mars

The advantages of using robots for these purposes are obvious. Firstly, the delivery of robots to the planet will be much cheaper because they do not need equipment to protect against cosmic radiation, different temperatures, and other hazards, which makes them a perfect option not only for flight but also for work in the environment of Mars that is unsuitable for humans. Secondly, unlike humans, robots do not require food, water, and air for life. This greatly reduces the complexity and cost of any mission to Mars since transferring goods from Earth to Mars is energy-, time-, and cost-intensive. Solar-powered robots can power themselves and operate for long periods of time without constant replenishment of resources. Thirdly, unlike humans, robots do not need time for rest and sleep. They can work on Mars for much longer periods of time, providing constant activity and continuously transmitting information back to Earth. This can significantly increase the efficiency and effectiveness of a Mars mission. Fourthly, the use of humanoid robots provides new opportunities for planetary exploration and allows researchers to push the boundaries of our knowledge of Mars. Robots can be equipped with scientific instrument suites that will allow them to conduct a wide variety of experiments and research on the planet's surface. They can collect soil samples, study climatic conditions, analyze atmospheric composition, and investigate the presence of underground resources.

2.2. Building an infrastructure

The primary and most important task for robots is to build a base on Mars. Using Earth-supplied building modules, 3D printing, and other specialized technologies, they will be able to build an infrastructure for future colonists. The robots will be able to build housing modules, warehouses, energy systems, and other necessary structures. The advantages of this approach include the ability for robots to work autonomously without the need for human presence and the high accuracy and speed of 3D printing.

2.3. Technology arsenal. Current robot developments

Figure 1 – The Atlas robot

There are many advanced technologies that can be utilized in this revolutionary mission. Some Android robot developments are described below. Atlas is one of the most advanced robots (Fig. 1) in the world, developed by Boston Dynamics. It allows for interacting with its environment thanks to its flexible construction. Atlas uses multiple sensors and three motors in each leg to move indoors and outdoors, maintain balance, and assume poses. It can also interact with objects. Atlas is equipped with sensors and cameras and can perform a wide variety of tasks. Boston Dynamics has recently demonstrated a new skill of the Atlas robot ─ now this humanoid robot is able to unpack and install automobile shock absorbers. This may mean that it will soon be applied not only in research projects but also in manufacturing [1].

Figure 2 – The Valkyrie robot

Valkyrie anthropomorphic robot (Fig. 2) created by NASA is a humanoid robot that will work alongside astronauts during space missions. The robot is 1.8 meters tall and weighs 131.5 kg. It is equipped with soft materials, which makes it comfortable to interact with the people around it. The purpose of using such robots is to reduce risks and hazards for astronauts while performing tasks in space. The main benefits of the Valkyrie robot and similar robots are that they can perform dangerous or boring tasks, freeing up astronauts for more important tasks. Such robots can protect astronauts from radiation, remove space debris, and work in extreme temperatures, making future space missions safer and more productive [2]. However, the robot is not autonomous, it is controlled by humans. NASA says it is being prepared for future lunar missions. At the same time, they admit that Valkyrie will never go into space. The purpose of the new tests is to gain more knowledge about designing robots for challenging environments.

The Valkyrie robot was first introduced in 2013 as a humanoid robot to work on space stations but has not yet been sent into space. Instead, it has been used as a research platform at several technological universities in the United States [3].

Another example is the Tesla Bot or Optimus humanoid robot, developed by Tesla, Inc. and unveiled at the AI Day event in August 2021. The Tesla Optimus robot (Fig. 3) is powered by self-learning artificial intelligence, neural networks and the Tesla autopilot. From April to September, the robot (the first prototype) learned how to walk. In the beginning, its movements were uncertain, slow, and clumsy but 6 months later the robot was able to move quickly, using hands as a body balancer. The robot has advanced color vision, which allows it to easily distinguish different objects, and with the help of vision Tesla engineers it was taught to navigate in real space and pick up objects. In December 2023, the new Tesla robot Optimus Gen 2 was released. The new version is equipped with all the actuators and sensors developed by Tesla. Significant changes include a new robot shell, a walking speed 30 % faster than in previous models, a robot weight reduced by 10 kg, improved body balance, new anatomically correct hands for manipulating different objects, and a redesigned foot structure [4].

Figure 3 – Tesla Bot or Optimus humanoid robots

2.4. The main obstacle to the effective use of robots in this project

However, a major obstacle to sending such robots to Mars is their lack of intelligence which is equal to or at least close to human intelligence.

At the moment, there are numerous intelligent robots and systems that have unique abilities to solve certain tasks. They have demonstrated high performance in specific tasks such as speech recognition, natural language processing, computer vision, and automatic control. However, it is important to note that these robots are not universal and are limited in their applications. Each intelligent robot or system has specific algorithms and models designed to solve a particular problem. If a task from a different domain needs to be solved, it often requires reprogramming or retraining, which can be a time-consuming process. At the heart of these robots are powerful machine-learning algorithms that require a lot of computational power and effort to train on large amounts of data.

The information and knowledge possessed by today’s intelligent robots are often stored on servers or in the cloud. This means that these robots depend on communication with powerful computing systems to access this information. Unlike humans, robots do not have internal individual knowledge and cannot simply retrieve relevant information from their memory.

On Mars, where robots will find themselves disconnected from databases and knowledge hosted on Earth servers, having individualized knowledge becomes critical. They cannot rely on constant communication with Earth to access information, as this may be difficult due to distance, time delays, or communication problems. Therefore, robots working on Mars must be self-sufficient in receiving and processing information. This problem forces developers of intelligent robots to explore methods of creating autonomous systems that can independently process data and make decisions based on individual knowledge. For robots working on Mars, having individual knowledge and the ability to make autonomous decisions is an important deciding factor that allows them to explore the environment, collect data on the geology, climate, atmosphere, and other aspects of Mars, and make decisions about how to proceed based on that data and experience.

Current research in the field of artificial intelligence and autonomous systems is in search of fundamentally new technologies that will allow robots to operate with limited or no connection to external sources of information. Instead of complete dependence on external resources, it is necessary to develop innovative methods and algorithms that allow robots to rely on their own knowledge and abilities to solve a wide range of problems in order to achieve their goals. One of the key areas of development in this area is the development of autonomous and adaptive systems. Such systems should have the ability to learn through experience, analyze data from the environment, adapt to new situations, constantly update knowledge, extract information from existing knowledge, and apply it to make decisions without the need to constantly refer to external sources.

3. Machine learning

Machine-learning algorithms and the currently popular deep neural networks play an important role in the development of intelligent systems. Modern intelligent systems and robots show impressive progress in the field of artificial intelligence and achieve significant success in solving various tasks. One of the brightest examples of such systems is chatbot GPT-4 (Generative Pretrained Transformer) and a neural network called DALL-E which generates images from text descriptions in a natural language. For example, the image of robots on Mars (Fig. 8) is generated by DALL-E from the following description: «Against the backdrop of a purple Martian sunset, the glint of the sun is reflected in the metal bodies of the robots, creating twinkling lights like stars that have come to Mars to help humanity explore a new world».

The GPT-4 and DALL-E chatbots are artificial intelligence models based on deep-learning neural networks [5]. GPT-4 has an incredible ability to generate text that seems almost indistinguishable from a human-generated one. It is trained on huge amounts of textual information, including content from the Internet and different sources, to gain extensive knowledge on a variety of topics. One of the major advantages of GPT-4 is its ability to understand natural language and generate answers based on the context and meaning of the question. It is able to answer various queries, share information, explain complex concepts, and maintain dynamic dialogs. When a user interacts with GPT-4, it feels like talking to a real person.

Modern intelligent systems demonstrate significant success in the field of games and solving complex problems. One vivid example is the chess match in which in 1997 world chess champion Garry Kasparov lost to the Deep Blue computer. The Deep Blue supercomputer, developed by IBM, made history as the first machine that managed to defeat a human grandmaster in chess. In 2016, a Go match took place between AlphaGo, a computer program developed by Google DeepMind, and one of the strongest professional Go players, Lee Sedol. For the first time, a computer program was able to defeat an outstanding human in this challenging game. AlphaGo's victory surprised the gaming community and confirmed the potential of artificial intelligence in gaming. In these matches, intelligent systems such as Deep Blue and AlphaGo demonstrated an enhanced ability to compute and analyze possible moves using massive amounts of data and powerful algorithms.

However, it is worth noting that these intelligent systems are still not general artificial intelligence. They are limited in the specific tasks for which they have been developed. Their abilities and functionality depend on specialized algorithms and models developed by experts in the relevant fields. Such systems mainly utilize the currently extremely popular deep learning algorithms. Deep learning is an advanced machine-learning technique based on multilayer neural networks used to process and analyze large amounts of data. Deep neural networks are formed from multiple layers, each of which makes its own unique contribution to information processing. Layer by layer, data flows through this organized structure, enriched with new layers of representation and insights. For example, in an image processing task, the first layers may begin with simple representations of shapes and textures, and subsequent layers refine details and discover more complex patterns such as contours and objects. At deeper layers, the network can recognize specific objects and classify them by understanding the content of images. Deep learning has an amazing ability to solve a wide range of problems from speech recognition to generated content such as music or images, to big data analysis and trend prediction. These powerful models can process huge amounts of information and discover complex patterns that enable progress and innovation in a variety of fields.

But despite that, along with the advantages of deep learning, there are a number of disadvantages to consider: deep learning requires huge datasets to train models efficiently; training deep neural networks requires large computational power, such as powerful processors and graphics processing units (GPUs); processing large amounts of data and complex models can be a resource-intensive process; training deep neural networks is a complex process that requires optimization and careful tuning of model parameters. Experiments with different architectures and hyperparameters should be conducted to achieve better results since deep neural networks are complex and difficult to interpret models. They work based on complex mathematical operations, and it can be difficult to exactly understand how a decision is made. In addition, despite impressive deep learning capabilities, these systems still lack true human-like understanding and awareness. All of these shortcomings require further research and development to overcome the limitations of deep learning and create more effective models and methods in the field of artificial intelligence.

Further development and research in the field of artificial intelligence should be aimed at creating more versatile and adaptive systems. An ideal direction of development is the construction of systems based on general artificial intelligence with its functional capabilities as close as possible to natural biological intelligence. Such systems will be capable of learning through experience, self-renewal, and adaptation to new situations. They will be able to apply their knowledge and skills in various fields, which will make it possible to make a significant step forward in the development and use of artificial intelligence in many areas of life.

However, the development of fully autonomous systems capable of complex solutions to a wide range of problems is a difficult task that requires the creation of artificial intelligence similar to human intelligence, a so-called strong artificial intelligence.

Strong artificial intelligence (AI) is a form of artificial intelligence that has the ability to solve problems that normally require human intelligence. Unlike existing artificial intelligence systems, such as highly specialized algorithms and machine learning methods, strong AI can think independently, make decisions, and is expected to possess consciousness. Such artificial intelligence is a system that is able to actively accumulate knowledge about the external world, learn from its own experience and the experience of others, adapt to changing conditions, and make decisions without direct human involvement.

There are different views on how to achieve strong artificial intelligence. Some scientists believe that improving existing machine learning algorithms and developing new methods of data processing are key factors. Others are of the opinion that it is necessary to develop a completely new neural network technology capable of self-awareness and purposefulness, similar to biological neural networks that make up the human brain. An example of such technology is multidimensional, multi-connected receptor-effector neural-like growing networks (mmreGN).

4. Multidimensional, multi-connected receptor-effector neural-like growing networks

MmrenGNs are a new type of neural networks. Models of these networks have shown the possibility of multilevel storage and processing of large volumes of concepts, images, events, or situations in various spatial representations such as tactile, visual, acoustic, and gustatory, through compression of information at each level, as well as multilevel control of executive mechanisms of robots or autonomous mobile intelligent systems. MmrenGN is created on the basis of analysis of scientific ideas reflecting regularities in the structure and functioning of biological structures of the human brain.

4.1. Biological structure of the human brain

The human brain consists of two hemispheres and is subdivided into four lobes. The frontal lobe is responsible for higher mental functions such as planning, problem-solving, and decision-making, and controls speech, writing, and body movements. The parietal lobe is responsible for speech interpretation and sound perception.

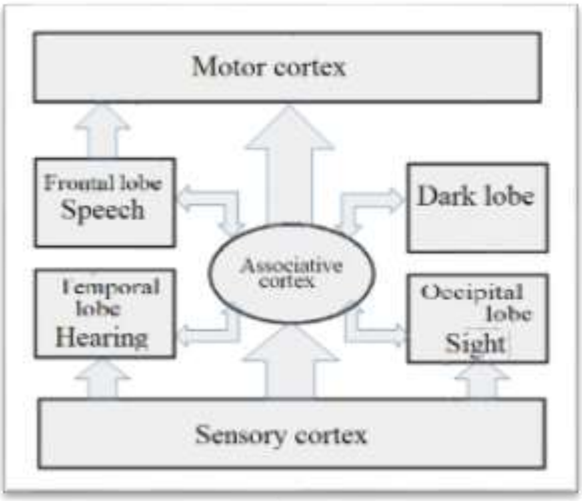

Figure 4 – Simplified functional diagram of the brain

The parietal lobe contains centers responsible for spatial and visual perception. The occipital lobe is responsible for processing visual information. The temporal lobe is responsible for hearing language and speech comprehension. These four major lobes of the brain work together, interacting with each other to ensure the normal functioning of various aspects of mental and physical activity. Fig. 4 shows a simplified structural diagram of the human brain.

4.2. Structure of a multidimensional, multi-connected receptor-effector neural-like growing network

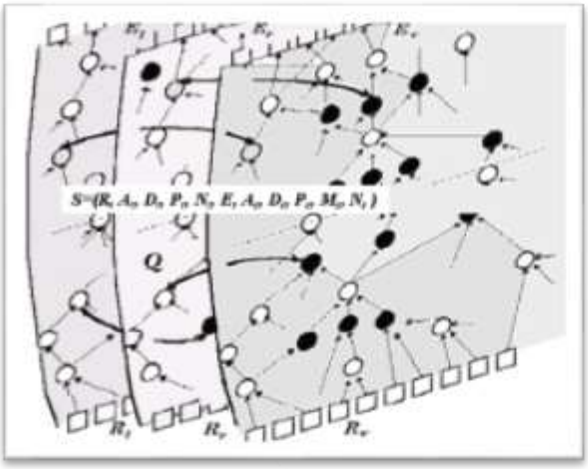

Figure 5 – Topological structure of mmren-GN

Multidimensional, multi-connected receptor-effector neural-like growing networks, using various spatial representations of information, perceive, memorize, and process descriptions of images of objects or situations in a problem area and also generate control actions on the external environment. Multidimensional, multi-connected receptor-effector neural-like growing networks are a set of interconnected two-way acyclic graphs that describe the state of an object and the actions it generates in various information spaces.

The topological structure of mmren-GN is represented by a graph (Fig. 5). Formally, mmren-GN is given as follows:

$$\boldsymbol{S = (R, A_r, D_r, P_r, M_r, N_r, E, A_e, D_e, P_e, M_e, N_e)},$$

with $\boldsymbol{R \supset R_v, R_s, R_t; A_r \supset A_v, A_s, A_t; D_r \supset D_v, D_s, D_t; P_r \supset P_v, P_s, P_t; M_r \supset M_v, M_s, M_t; N_r \supset N_v, N_s, N_t; E \supset E_r, E_{d1}, E_{d2}; A_e \supset A_r, A_{d1}, A_{d2}; D_e \supset D_r, D_{d1}, D_{d2}; P_e \supset P_r, P_{d1}, P_{d2}; M_e \supset M_r, M_{d1}, M_{d2}; N_e \supset N_r, N_{d1}, N_{d2}}$; and where $\boldsymbol{R_v, R_s}$, and $\boldsymbol{R_t}$ are a finite subset of receptors; $\boldsymbol{A_v, A_s}$, and $\boldsymbol{A_t}$ are a finite subset of neuron-like elements; $\boldsymbol{D_v, D_s}$, and $\boldsymbol{D_t}$ are a finite subset of arcs; $\boldsymbol{Pv, Ps}$, and $\boldsymbol{Pt}$ are a finite set of excitation thresholds of neuron-like elements of the receptor zone, belonging, for example, to visual, auditory, and tactile information spaces; $\boldsymbol{N}$ is a finite set of variable connectivity coefficients of the receptor zone; $\boldsymbol{E_r, E_{d1}}$, and $\boldsymbol{E_{d2}}$ are a finite subset of effectors; $\boldsymbol{A_r, A_{d1}}$, and $\boldsymbol{A_{d2}}$ are a finite subset of neuron-like elements; $\boldsymbol{D_r, D_{d1}}$, and $\boldsymbol{D_{d2}}$ are a finite subset of effector arcs zones; $\boldsymbol{P_r, P_{d1}}$, and $\boldsymbol{P_{d2}}$ are a finite set of excitation thresholds of neuron-like elements of the effector zone, belonging, for example, to the speech information space and action space; $\boldsymbol{N}$ is a finite set of variable connectivity coefficients of the effector zone.

Thus, in mmren-GN information about the external world, its objects, their states, and situations describing the relationship between them, as well as information about the actions caused by these states, is stored due to its reflection in the network structure, and the arrival of new information causes the formation of new associative nodes and links and their redistribution between the nodes that have arisen earlier, while the common parts of these descriptions and actions are identified, which are automatically generalized and classified.

4.3. Structure of the artificial brain based on mmren-GN

A simplified scheme of the artificial brain based on a multidimensional, multi-connected receptor-effector neural-like growing network is presented in Fig. 6 and includes several basic areas and structures.

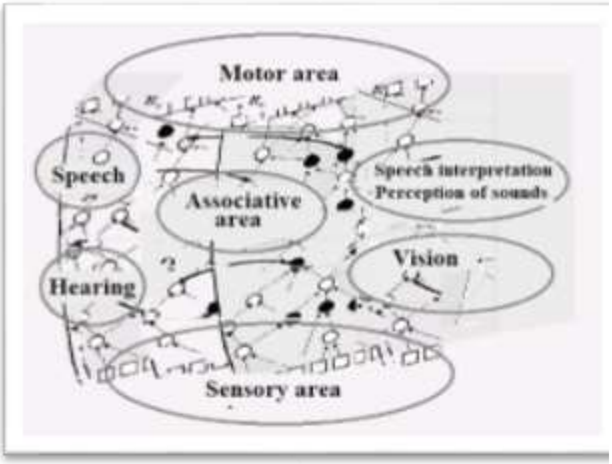

Figure 6 – Simplified scheme of the artificial brain in the mmren-GN structure

At the beginning of the functioning of the artificial brain, a sensory area is formed in the mmrenGN. In this area, sensory neural ensembles receive and process sound, visual, tactile information, temperature, etc., with the help of appropriate devices and sensors. Receptors in the sensory area react to various attributes and characteristics describing objects and concepts. At the first level of the sensory area, neuronal ensembles are formed that contain coinciding features of descriptions of specific concepts, for example, such as parts of the human body. The second level includes more general concepts, such as the description of a person as a whole. In the process of information perception and learning, associative domain and related structures are generated, which are responsible for hearing, speech, interpretation, and understanding of speech, personality formation, behavior, and emotions. Based on the received information and accumulated knowledge, different levels of active neural ensembles are formed, which are responsible for storing concepts, planning actions, making decisions, and organizing behavior.

At each level, information is encoded to reduce its descriptions. An artificial brain based on mmren-GN is a system including sensory area, associative structures, and ensembles of active neurons that interact to process and analyze information and implement actions.

This structure of the mmren-GN makes it possible to form meanings as objects and connections between them as the information is perceived and the network itself is built. In this case, each sense (concept) acquires a separate component of the network as a vertex connected with other vertices. In general, this corresponds to the structure reflected in the brain, where each explicit concept is represented by a certain structure and has its own denoting symbol. The network is practically free from restrictions on the number of neuron-like elements in which to place the corresponding information, i.e. to build the network itself, representing the given subject area. In addition, the network acquires increased semantic clarity due to the formation of not only links between neuro-like elements but also the elements themselves as such, i.e. there is not just the construction of a network by placing semantic structures in the environment of neuro-like elements, but, in fact, the creation of this environment itself, as the equivalent of the memory environment. Thus, neural-like growing networks appear to be a convenient apparatus for modeling the mechanisms of purposeful thinking, as a fulfillment of certain psycho-physiological and psychological tasks.

In neural-like growing networks, information is stored as a consequence of its reflection in the network structure. Multidimensional neural-like growing networks are represented by a multilevel, multidimensional structure reflecting the structure of the described classes of objects. Information about objects and their classes is represented by ensembles of associatively interconnected vertices distributed over the network structure. The input of new information into the network causes the process of building its structure (redistribution of connections between existing and newly appearing vertices) with simultaneous excitation of neuro-like elements. As a result of this process, the described object is included into the class to which it belongs, or a new class of objects is formed. This is how the classification and selection of common features of objects are carried out. The algorithm of network construction automatically establishes associative links between descriptions of objects based on their common features. The description of an object or a class of objects is localized in some part of the network, which allows it to efficiently perform various associative search operations. The cost-effectiveness of information representation in n-RS is realized due to information compression at each level, as well as due to the fact that identical combinations of features of several objects are represented by one common subset of network vertices.

Training of the network is carried out simultaneously with its construction in accordance with the rules of construction and functioning of the network. An important property of mmr-RS is the ability to form control actions on the external environment (i.e., to train the network to generate control signals in the effector zone), in accordance with the knowledge acquired by the network as a result of accumulation, analysis, classification, and generalization of information from the external world (i.e., information processing in the receptor zone of mmr-RS). In the case of the hardware realization of mmr-RS, this property becomes even more important (especially when building robotic systems) due to the possibility of parallel processing of information and the generation and delivery of control actions to the outside world [6, 7]. Although mmr-RS is still at the stage of research and modeling, it is already clear that this is an ideal structure for building an artificial brain for Android robots and building a strong AI.

5. Mars rover robot missions

The use of robots on other planets is of great importance for scientific research and space exploration. Mars rovers such as Curiosity and Mars 2020 are active on the surface of Mars collecting soil samples, photographing the planet, and conducting research. These rovers are helping scientists expand our understanding of Mars and its history.

Figure 7 – ARMADAS system

Despite some setbacks, robots still play an important role in space exploration. They make it possible to explore distant planets and reduce the risk that humans face when performing complex tasks in outer space. In addition, robots provide valuable data on the composition of planets and other space objects and help improve our technology for future missions and space colonization.

Robotic systems capable of self-assembling and building various structures on other planets are also being developed. A NASA team is developing the Automated Reconfigurable Adaptive Reconfigurable Adaptive Digital Assembly System (ARMADAS), which uses a variety of robots, including “worm-like” robots, to assemble and reconfigure materials (Fig. 7).

They work as a team, using three-dimensional building blocks to create a variety of structures. This technology is programmable and able to reconfigure itself to suit the task at hand. Potential applications of this technology include the creation of colonies and infrastructures on other planets, reducing the dependence on sending large pre-assembled structures from Earth. This opens up new opportunities for space exploration and infrastructure construction on other planets without having to bring all the materials from Earth [8].

6. Expedition of humanoid robots to Mars

Elon Musk, CEO of SpaceX, plans to create a small colony on Mars. For this purpose, it is supposed to develop a special transportation system that functions in the conveyor belt mode. However, at the moment, only a system for reusing rockets has been successfully developed. Musk estimates the cost of creating such a system at 10 billion dollars and considers it possible to send to Mars one-time up to 100 passengers. These would be tourist trips sent every 26 months when Earth and Mars are in maximum proximity. The first missions may require sacrifices. Nevertheless, there are already people willing to make the one-way trip [9]. Before sending humans to Mars with no guarantee of return, it is better to send intelligent Android robots to prepare the conditions for receiving humans and thus help humanity colonize Mars (Fig. 8).

Figure 8 – Robots on Mars
(an image generated by DALL-E
from text description)

This is not only more economical but also more efficient. Mars is a very inhospitable environment for human life. It has a thin atmosphere, high radiation levels, low gravity, and extreme temperature variations. The average temperature on Mars drops to -46°C, but can drop to -143°C and warm up to 35°C. Dust storms, changing seasons, and other atmospheric phenomena make Mars a unique object. In order for humans to survive and work on Mars, they will need a great deal of specialized equipment, such as protective spacesuits, living modules, life support systems, etc. All of this significantly increases the cost and complexity of the mission. Androids, on the other hand, can do without all that. They do not need sci-fi suits and other equipment to move on the surface of Mars, nor are they subject to physical wear and tear and fatigue from unfavorable conditions. They can work around the clock, conduct research, carry out analyses using modules supplied from Earth, and build infrastructure to welcome astronauts, colonists, and tourists. Robotic Androids with artificial brains, possessing a high level of intelligence, are able to make independent decisions based on analyzing the received information and their experience, without requiring constant commands from Earth.

Sending Androids to Mars is the best way to prepare the planet to receive humans and to avoid risks to astronauts’ lives and health. In general, sending Android robots with artificial brains to Mars is an economically justified step that not only reduces risks and costs but also speeds up the process of colonizing and exploring this fantastic planet.

7. Conclusions

The article describes the advantages of using highly intelligent human-like robots in preparation for the colonization of Mars. Exploring the Red Planet with humanoid robots holds significant promise for understanding it and preparing a base for future settlers. Robots can conduct geological surveys, analyze soil and landscape composition, study the atmosphere, and build basic infrastructure. These tasks can help to determine the availability of useful resources, plan life support, and create a comfortable environment for future settlers. The use of such robots can reduce the cost of missions, avoid risks associated with protection from radiation and extreme conditions, and ensure continuous activity on Mars without the need for constant replenishment of resources. The article also examines the modern development of humanoid robots such as Atlas, Valkyrie, and Optimus. It is noted that Android robots do not yet have human intelligence and require human interaction and control. However, the development and use of robots is an important step in preparing for the colonization of Mars and the implementation of complex tasks in an environment unsuitable for humans. To solve this problem, it is proposed to use multidimensional, multi-connected receptor-effector neuron-like networks to create an artificial brain that is as close as possible to the human brain.

Overall, the article highlights the importance and benefits of using robots in future missions to Mars, moving humanity closer to safer and more productive exploration and colonization of the Red Planet.

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