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DECISION-MAKING TECHNOLOGIES IN MILITARY SYSTEMS. CHALLENGES AND PROSPECTS

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Анотація. *Стаття розглядає актуальні аспекти використання інтелектуальних систем у військовій сфері та їх роль у прийнятті рішень у кризових ситуаціях. Зокрема, аналізуються такі системи, як JADE, ALPHA та R-Plan, призначені для планування розгортання збройних сил, управління бойовими літаками та прийняття рішень на оперативному рівні. Стаття також визначає технологію прийняття рішень в автоматичних та автоматизованих системах управління, а також стан сучасних військових технологій. Особлива увага приділяється ролі технологій прийняття рішень у військових діях, виявляються виклики та перешкоди, з якими стикаються подібні системи. Для ефективного подолання цих перешкод розглядаються перспективні напрями розвитку та покращення технологій. Стаття дозволяє отримати огляд поточного стану та майбутніх перспектив у галузі використання інтелектуальних систем для підтримки рішень у військовій сфері, а також виявити ключові фактори, що впливають на їхнє ефективне застосування. У статті обговорюється інноваційний підхід до створення розумних автономних роботів на основі нової технології нейроподібних мереж, що ростуть (мрен-РС). Роботи, створені з використанням цієї технології, оперують на основі знань, асоціативних зв'язків та логічного висновку, постійно вдосконалюючи свій інтелект. Такі роботи не вимагають складних обчислювальних систем завдяки простій структурі нейроподібних елементів. Їхня висока ефективність забезпечується масовим паралелізмом обробки інформації. Роботи на базі мрен-РС можуть самостійно навчатися, приймати логічні рішення та динамічно коригувати свої дії. Переваги включають високий інтелект, ефективне енергоспоживання, надійність та стійкість до перешкод. Такі роботи мають потенціал стати надійними помічниками у вирішенні складних завдань та зробити значний внесок у розвиток суспільства, а також змінити уявлення про майбутню цивілізацію.*
Ключові слова: *технологія прийняття рішень, автоматичні та автоматизовані системи, інтелектуальні системи, нейроподібні зростаючі мережі.*

Abstract. *This article examines the current aspects of the use of intelligent systems in the military sphere and their role in decision-making in crisis situations. In particular, systems such as JADE, ALPHA, and R-Plan designed to plan the deployment of armed forces, control combat aircraft, and make decisions at the operational level are analyzed. The article also describes the decision-making technology in automatic and automated control systems, as well as the state of modern military technologies. Particular attention is paid to the role of decision-making technologies in military operations, and the challenges and obstacles faced by such systems are identified. To effectively overcome these obstacles, promising directions for development and technology improvement are considered. The article provides an overview of the current state and prospects of the use of intelligent systems for decision support in the military sphere and identifies the key factors influencing their effective application. The paper discusses an innovative approach to the creation of smart autonomous robots based on the new technology of neural-like growing networks (mren-RS). Robots created using this technology function based on knowledge, associative connections, and logical inference, constantly improving their intelligence. Such robots do not require complex computing systems due to the simple structure of neural-like elements. Their high efficiency is ensured by the massive parallelism of information processing. Robots based on mren-RS can learn independently, make logical decisions, and dynamically adjust their actions. Their advantages include high intelligence, effi-*

cient power consumption, reliability, and resistance to obstacles. Such robots have the potential to become reliable assistants in solving complex problems, make a significant contribution to the development of society, and change the idea of a future civilization.
Keywords: *decision-making technology, automatic and automated systems, intelligent systems, neural-like growing networks.*

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1. Introduction

In the modern world, fast and accurate decision-making during military operations has become undeniably important. The development of artificial intelligence technologies, machine learning, and automated control systems opens up new prospects for improving military tactics and strategy.

Intelligent systems are technical or software solutions capable of performing tasks that were previously considered creative. They have domain-specific knowledge stored in their memory [1]. In the military domain, such systems actively assist commanders and staff in planning, analyzing, predicting, and managing military operations, as well as ensuring compliance with legal and ethical standards.

The aim of this article is to explore the role and current state of decision-making technologies in military systems and highlight the challenges and prospects of their future development.

2. Modern intelligent systems in the military field

Intelligent systems for military decision-making typically consist of three key components: a knowledge base, an inference engine, and a user interface. The knowledge base contains facts and rules about the subject area, for example, about the characteristics of own and enemy troops, geographical and climatic conditions, the objectives of the operation, and so on. The inference engine uses logical or statistical methods to analyze information obtained from the knowledge base and generate recommendations or alternative solutions. The user interface provides interaction between the intelligent system and a person, allowing data to be presented in graphical or textual form.

In the European Union, the JADE system supports strategic decision-making by analyzing crisis scenarios and optimizing action strategies. The Joint Assistant for Development and Execution (JADE) is a US military system used to plan the deployment of military forces in crisis situations [2]. The name “JADE” comes from the jade green color of the island of Oahu in Hawaii, where the US Pacific Command (PACOM) is headquartered.

The US military developed this automated software system to speed up the creation of detailed plans needed to position military forces during military operations. To achieve this, JADE uses artificial intelligence that combines user input, a knowledge base of previously saved plans, and system recommendations to enable the creation of complex and large-scale plans in the shortest possible time.

In 1999, the Joint Operations Planning and Execution System (JOPES) was used to manage US military deployment planning. The JADE tool for automated crisis planning was developed by BBN Technologies as a part of the DARPA-facilitated ARPA-Rome planning initiative. Subsequently, JADE was successfully demonstrated and integrated into the Global Command and Control System (GCCS) as well as the Adaptive Course of Action (ACOA) environment, meeting Defense Information Infrastructure (DII) requirements [3].

A document called the Human Systems Roadmap Review which was released to the public in 2016 outlined the plans to develop autonomous weapons systems. They involve analyzing social networks and making decisions, including the use of lethal force, with minimal human intervention. This type of system is called a Lethal Autonomous Weapon System (LAWS) [4].

DARPA is an agency of the United States Department of Defense that funds and oversees research and development in various areas of technology for military purposes. Its main goal is to invest in breakthrough technologies that contribute to national security. One of the key areas that DARPA is focusing on is artificial intelligence (AI). It involves the science and engineering aimed at creating machines and systems capable of performing tasks that require human intelligence, such as reasoning, perception, learning, decision-making, and problem-solving. Since its founding in 1958, DARPA has been involved in AI research and has supported many innovative projects such as the first expert system, the first self-driving car, and the first humanoid robot.

Among modern projects related to AI and funded by DARPA, ALPHA – an intelligent system for controlling combat aircraft and air battles – is worth highlighting. It was developed by a team of researchers led by Professor Nick Earnest at Psibernetix Inc. The system uses a new genetic fuzzy tree (GFT) method that combines evolutionary algorithms and fuzzy logic for efficient real-time decision-making. ALPHA has demonstrated its ability to defeat experienced pilots in simulated dogfights, causing delight with its aggressiveness, responsiveness, and dynamism [5].

R-Plan is an intelligent decision support system at the operational level developed by the German Aerospace Center (DLR) and the Fraunhofer Institute for Industrial Mathematics (ITWM). R-Plan uses operations research and artificial intelligence techniques to solve complex optimization problems in various fields such as logistics, transportation, manufacturing, energy, and healthcare.

The R-Plan system consists of three main components: a data management module, a modeling and optimization module, and a visualization and interaction module. The data management module collects and integrates data from various sources such as sensors, databases, or web services. The modeling and optimization module uses mathematical models and algorithms to find optimal or near-optimal solutions to a given problem. The visualization and interaction module provides convenient interfaces and tools for displaying and analyzing results, as well as for modifying input parameters or goals.

R-Plan's goal is to improve the efficiency and effectiveness of operational decisions by reducing costs, saving time, and improving quality and sustainability. In addition, R-Plan aims to support decision-makers by providing them with reliable information, transparent explanations, and flexible options [6].

In general, intelligent systems for military decision-making play a significant role by providing more accurate data analysis, prediction, and optimization of strategies. However, their effectiveness always depends on the quality of the data and the ability of the team to adequately interpret the results of the system. In the future, the development of these technologies may help to achieve even more accurate and rapid results in military operations.

3. Decision-making technology in automatic and automated control systems

Decision-making technology in automatic and automated control systems is an integrated approach to data analysis and the selection of optimal actions based on the specified criteria. It includes the use of various methods, algorithms, and models for effective process management and decision-making.

To carry out the decision-making procedure, it is necessary to turn the data into a decision along the chain: data – information – knowledge – decision-making – execution of the decision made.

Data are quantitative or qualitative characteristics of the state of an object, obtained at a certain time at certain points. The system collects data from various sources such as databases and external information sources. This data can be numeric values, text information, images, videos, or materials in other formats. If d_i is a unit of data, then for the object we have is, $\sum_{i=1}^{m} d_i$ where m is the amount of data necessary to monitor and manage the object [7].

Then the system analyzes the data to identify patterns, trends, correlations, and other useful patterns. Depending on the problem, this may involve the use of statistical methods, machine learning, artificial neural networks, and other analytical approaches. An important part of the technology is the creation of models and simulations to analyze possible scenarios and the consequences of various decisions. This allows for assessing the impact of decisions on future events and determining the best options.

Based on data analysis and simulations, the system develops various action alternatives that may vary in strategy, execution time, resources, and other parameters. For each alternative, evaluation criteria that allow the system to compare their effectiveness are defined. These criteria may include economic, time, technical, and other indicators. Based on the evaluation results, the system selects the optimal solution that best suits the goals, constraints, and requirements. The chosen solution is put into action, whether it involves automatic control, operator commands, or other actions.

The system monitors the execution of the solution and collects new data. If the situation changes, the system can adjust the decision or offer new alternatives based on new circumstances.

Decision-making technology in automatic and automated control systems allows you to effectively respond to changes and optimize processes in real time, ensuring the achievement of set goals and optimal use of resources.

An automatic control system is understood as a system that without outside intervention continuously performs its target transformation function on time: data – information – knowledge – decision-making – execution of the decision made. A separate class of automatic systems is work. The robot is an automatic control system that can improve and expand its target function by independently acquiring additional knowledge to that initially acquired by a person. Currently, artificial intelligence already makes it possible to create single-functional works. These are, for example, a robot car, a robot surgeon, an aircraft, etc. With the advent of AI, taking into account its capabilities, the class of automatic systems has sharply expanded [7].

4. The state of modern military technology

Autonomous combat systems are of great importance in the field of modern military technology and are not inferior in importance and presence on the battlefield to the most advanced innovative developments. The importance of these developments stems from the fact that they can bring significant improvements in military strategy and tactics, as well as make operations more efficient and safer for military personnel. Autonomous robotic systems have become an integral part of combat strategies. Unmanned aerial vehicles (UAVs), robots, and even autonomous battle tanks are used in military operations for tasks such as reconnaissance, attacks, and defense missions. They can penetrate the most dangerous areas, minimizing the risks to the lives of soldiers. On modern battlefields, where every second can determine the battle outcome, such autonomous systems become reliable allies in supporting operations.

In modern military operations, where information is the key to success, prediction and data analytics technologies play an important role. Large volumes of data on troop movements, weather conditions, the presence of enemy forces, and other factors become puzzles from which critical pieces of strategy are formed. Machine learning capabilities allow for processing this data, identifying patterns and trends, predicting enemy actions, and adapting tactics and strategies in real time.

Weapons are not limited to just physical combat systems. Modern warfare increasingly involves cyberattacks and defenses. In a world where information and control over digital assets are of the utmost importance, automated analysis and real-time decision-making systems are becoming indispensable tools for identifying and neutralizing cyber threats. They can detect enemy attacks, anomalies, and vulnerabilities, thereby enhancing cybersecurity in the context of digital warfare.

Thus, the current state of decision-making technologies in military systems shows that military strategy and tactics continue to evolve against the backdrop of rapid technological development. From autonomous combat systems that can replace soldiers in dangerous environments to the ability to analyze large volumes of data and provide cybersecurity, all this allows for more efficient and secure military operations.

5. The role of decision-making technologies in military operations

In the fast pace of military operations, even the slightest slowdown can be costly. This is where decision-making technologies come into play, allowing you to quickly respond to a changing environment. Automated systems can analyze huge amounts of data in real time and make strategic recommendations, or even automatically make decisions based on predefined parameters. This is especially true in military conflicts, where every second is crucial. Automatic decision-making systems allow you to quickly coordinate the actions of various departments and adapt strategies to a changing situation.

The most advanced and innovative developments in military technology always strive to minimize the risks to the lives of soldiers. One prominent example here is the autonomous combat systems that have become an integral part of modern military operations. Unmanned aerial vehicles (UAVs), autonomous battle tanks, and robots perform reconnaissance, attacks, and defense missions without the need for direct human intervention. This allows for reducing risks for military personnel, relieving them from performing dangerous tasks. These autonomous systems are equipped with sensors that allow them to assess the situation in real time and make decisions based on data analysis, making them more efficient and accurate in completing tasks.

The collection and analysis of large volumes of data play a key role in military operations. Here, decision-making technologies based on machine learning and artificial intelligence algorithms show themselves in all their glory. These systems are capable of analyzing information about troop movements, meteorological conditions, the presence of enemy forces, and other factors. Based on the obtained data, they can predict enemy actions and adapt strategies in real time. This allows military teams to quickly respond to changing situations and build more accurate strategies and tactics based on evidence and trend analysis.

Modern warfare is not limited to just the physical battlefield. They also include digital aspects, including cyberattacks and cyber defense. In this area, decision technologies are becoming a key tool for detecting and preventing cyber threats. Automated data analysis and anomaly detection systems can scan networks and systems for unusual activity that could indicate a potential cyberattack. Such systems can automatically respond to detected threats by blocking malicious software, preventing unauthorized access, and protecting crucial military assets and data.

Military decision-making technologies have a significant impact on the course of events on the battlefield, helping to increase responsiveness, improve analytics, reduce risks to military personnel, and ensure cybersecurity. However, as in any field, this technology has its own challenges and prospects.

5.1. Challenges and obstacles

Modern automatic decision-making systems have a number of challenges that require attention. These are the following:

1. Cybersecurity. Decision-making systems are subject to cyberattack threats and impacts. Attackers may try to influence decision-making or even seize control of the system. This poses a risk to transaction security and data privacy.

2. Learning from limited data. Many machine learning systems require large amounts of training data. However, in some situations, especially in the military sector, access to large amounts of data may be limited.

3. Transparency and explainability. Complex algorithms and artificial neural networks can be difficult to understand and explain. This can cause quite a lot of problems, especially in situations where it is necessary to understand how and why a particular decision was made.

4. Balance between automation and human control. It is important to find the right balance between automated decision-making systems and human intervention. Too much automation can lead to the loss of control, and too much human intervention can degrade system performance.

5. Dependence on radio control. One major obstacle remains the dependence on radio control, which makes robots vulnerable to electronic interference. As a result, the loss of control over the devices can negatively affect the success of military operations. An important factor also remains that, despite the use of unmanned aerial vehicles and technical means, the main losses still fall on the infantry, which participates in offensive operations and the liberation of territory. This raises the need to ensure the safety of soldiers on the battlefield and reduce casualties.

6. Ethical dilemmas. As decision-making technologies advance, complex ethical dilemmas arise. In particular, autonomous systems may encounter situations where the choice between life and death may be left to the algorithm. Who is responsible in case of an error: the developer, the operator, or the system itself? It is necessary to develop regulations and laws governing the use of such technologies.

5.2. Overcoming obstacles

It is necessary to address the issues of overcoming obstacles:

1. Learning from limited data. Developing methods for learning from limited data is becoming an important challenge and an active area of research.

2. Ethics and transparency. It is important to design understandable and ethical algorithms.

3. Security. Ensuring the reliability and security of such systems becomes an integral part of their development.

4. Regulation. Appropriate standards and regulations need to be developed to ensure the safety and effectiveness of such systems, as well as to resolve potential disputes and conflicts associated with automated solutions.

5. Dependence on radio control. Autonomous robots should be developed. Despite significant advances in artificial intelligence, robots still rely on programming and may encounter unexpected situations that are difficult to anticipate.

5.3. Promising directions for overcoming obstacles

To understand the future development of decision systems, it is necessary to look at the prospects of this field, which promise significant expansion, innovation, and application in a wide variety of fields. After all, these technologies are already actively changing the course of military operations and influencing strategic and tactical decisions.

In order for robots to effectively adapt to complex and constantly changing battlefield situations, the development of intelligent autonomous robots with human-like artificial brains is required. The concept of an artificial brain refers to the creation of a computer system capable of imitating the structure and functions of a real human brain. This artificial brain can be implemented through a variety of techniques, including neural networks, genetic algorithms, and cognitive architectures. It has various aspects, including memory, concentration, emotions, language, and even consciousness. The introduction of an artificial brain into a robot provides it with intellectual capabilities.

There are several large-scale global projects aimed at modeling the human brain: Human Brain Project, Blue Brain, Brain/MINDS, China Brain Project, Artificial Brain Project (Thinking Computer), etc.

The Artificial Brain project is a Ukrainian direction in computerization that uses new unconventional technology for simultaneous processing of various types of information in a single multidimensional neuron-like structure [8]. This technology is designed to create a new type of intelligent machines that can think like humans. The main feature of the new technology is the creation of a multidimensional neural-like growing network (mren-GN), functioning similarly to the human brain. This network has many interneuron connections, as well as the ability to simultaneously process a variety of information such as video, sound, and text at different levels of complexity. It is also capable of forming reflexes and associations.

The difference between this technology and classical neural networks lies in its growing and universal structure. It is formed by information and allows all neurons of the network to work simultaneously, providing massive parallelism. This technology allows for performing various operations with information such as perception, analysis, synthesis, memorization, and associative search. In addition, mren-RS is capable of generating control signals for actuators based on the analysis of the perceived information. This allows for creating unconditioned reflexes and performing a number of complex tasks [9, 10].

So, the Artificial Brain project introduces a new technology that uses a multidimensional neural-like network to process a variety of information and imitate some aspects of human thinking. To create an artificial brain, a hardware implementation of this technology is required.

Created using the new technology of neural-like growing networks, smart autonomous robots are different from conventional systems. They are based on the principles of knowledge, analogies, associations, and logical inference, are constantly being improved, and operate in a manner similar to that of a human. These robots do not require powerful computing systems, since the neural-like elements are simple and effective. Their strength lies in massive parallelism which allows them to simultaneously perceive and process information.

Neural-like growing networks provide high-speed operation, operating throughout the entire structure simultaneously. And what is interesting is that they process more information faster, creating opportunities for dynamic decisions. What is important is that such robots do not require traditional programming. They use accumulated knowledge and the ability to learn, consult, and reason to solve problems. These robots have high intelligence which is constantly being improved and is able to discover new patterns. They can become reliable helpers, solving problems and contributing to the development of society. The advantages of such systems include small size, efficient power consumption, immunity to interference, and high reliability.

Thus, smart autonomous robots based on neural-like growing networks are approaching human intelligence and can solve almost all problems of overcoming obstacles in decision-making technologies.

6. Conclusions

By analyzing modern intelligent systems in the military field, a number of important conclusions can be drawn. Initially, systems such as JADE, ALPHA, and R-Plan represent significant technological advances that facilitate effective force planning, combat management, and operational decision-making. However, despite their existing advantages, these systems also face challenges related to safety, ethics, and unexpected situations on the battlefield.

Decision-making technology in automatic and automated control systems continues to evolve, striving to create more intelligent and adaptive solutions. These advances have the potential to change the dynamics of military operations, enabling missions to be accomplished more accurately, quickly, and efficiently.

The role of decision-making technologies in warfare is becoming increasingly important. However, the deployment of autonomous weapons systems such as LAWS raises complex ethical and legal issues that require careful consideration and regulation. It is important to find a balance between system autonomy and maintaining human control over critical decisions on the battlefield.

Overcoming barriers to the development of intelligent systems for military applications requires further research and innovation. Promising directions include the development of more integrated and adaptive systems that can more effectively analyze and respond to dynamically changing situations on the battlefield.

Overall, modern decision-making technologies play an important role in improving the speed, accuracy, and adaptability of military operations. However, their successful implementation requires a careful balance between technical feasibility and ethical considerations to ensure safety, effectiveness, and compliance with standards and principles.

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