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SUPPORT SYSTEMS FOR ROBOTICS: PRINCIPLES, ALGORITHMS AND DEVELOPMENT PROSPECTS

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ABSTRACT

The article explores the current state and prospects for the development of decision support systems in robotics. It examines the fundamental principles of building such systems, in particular hierarchy, information integration, adaptability, and others. The main algorithmic approaches are analyzed, including Q-learning, neural networks, Markov processes, genetic algorithms, fuzzy logic, and Bayesian networks. Mathematical models and examples of practical applications of each algorithm are provided. A comparative analysis of the effectiveness of various algorithmic solutions is conducted based on the criteria of adaptability, speed, and implementation complexity. The advantages and limitations of each approach are identified in the context of specific robotics tasks. Prospective directions for the development of DSS are outlined, focusing on integration with modern deep learning technologies, cloud computing, and quantum systems. The research has theoretical and practical value for the development and improvement of autonomous robotic systems in various fields of application, from industry to medicine. The results of the work can be used in the design of new and modernization of existing decision support systems in robotics.

Keywords: robotics, support systems for solutions, piece intelligence, machines, intelligent algorithms.

1. INTRODUCTION

Modern robotics is developing at a rapid pace, integrating advanced technologies of piece intelligence, analysis of data and automation of activities [1-7]. One of the key aspects of autonomous and autonomous robotic systems is the ability to receive a solution in the real hour mode. For this purpose, the solution support system (DSS) is used as a unified mathematical model, optimization algorithms, and machine generation methods for information analysis and selection of the best action.

DSS plays an important role in various areas of robotics, including industrial work, transport safety, medical and service work. To ensure adaptability, avoidance and safety, which are critically important factors for work in dynamic and unrestricted environments.

The relevance of those is confirmed by the growing demand on autonomous robotic systems both in Ukraine and beyond. In Ukraine, the active development of robotics is being promoted in the domestic sector (development of non-radioactive systems), the agricultural sector (automated drones and works for precision earthwork) and industry. World trends also demonstrate a wide integration of DSS in production, medicine and transport, as well as the increase in efficiency, the reduction of human consumption and minimization.

The need for DSS in robotics is due to the following factors:
1. The increasing complexity of robotic systems:
- modern robots are becoming more complex and multifunctional,
- the number of parameters and variables that need to be taken into account when making decisions increases,
- there is a need to process large amounts of data in real time.
2. Need for autonomy:
- the demand for robots capable of independent decision-making in dynamic conditions is growing,
- the need for a quick response to environmental changes,
- minimization of human intervention in the work process.
3. Reliability and safety requirements:
- the critical importance of the right decisions in industry and medicine,
- the need to prevent emergencies,
- ensuring the safety of interaction with people.

In this work, it is planned to consider the basic principles of DSS construction, key decision-making algorithms and their application in robotic systems. Special attention will be paid to the prospects for the development of such

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systems in the context of expanding the autonomy of robots and integrating advanced artificial intelligence technologies.

2. ANALYSIS OF PUBLICATIONS

Research in the field of decision support systems in robotics is actively developing, since autonomous robotic systems require effective mechanisms for analyzing data and choosing optimal actions.

The main directions of development of the DSS and modern expert systems in various areas of application are described by us in [8]. The paper analyzes the advantages and disadvantages of expert systems, as well as the main components of typical expert systems. Special attention is paid to the features of such systems, in particular, criteria for their applicability are proposed. Within the framework of the review, a classification of expert systems was carried out according to nine characteristics, which differs from the existing ones in that it takes into account the peculiarities of the use of systems and the type of computer. A general analysis of the use of expert systems in various fields – from industry to agriculture – over the past two years has also been carried out.

The use of DSS in agricultural robotics is described in [9]. Agricultural robotics in the context of Agriculture 4.0, which aims to increase productivity, rational use of resources, adapt to climate change and minimize food waste. Thanks to modern information technologies and analysis of large amounts of data (e.g. meteorological conditions, soil conditions, market demand), such systems help farmers make effective decisions and increase profitability.

The use of robotic systems in surgery that significantly reduces patient recovery time, automates repetitive tasks for surgeons, allows access to hard-to-reach areas, and provides real-time feedback, which helps reduce surgery time and reduce cognitive workload described in [10]. The work focuses on computer vision research in surgery, which contributes to improving safety and supporting decision-making in the surgical process.

The paper [11] examines the use of DSS for adaptive design of experiments in robotics, in particular for field robots operating in complex, unstable real-world environments. Given the complexity of such systems, the authors propose the use of DSS to improve decision-making by people conducting experiments, helping to minimize costs and risks while increasing the informational value of experiments. Intelligent DSS (IDSS), which include elements of artificial intelligence to improve robot workflows and evaluate their performance in real conditions, are considered separately. The study also proposes a six-stage classification of such systems, and also identifies the main problems and directions for further research in this area.

The work [12] is devoted to the study of the application of the simple additive weighing (SAW) method in a decision support system for robotics in order to improve the decision-making process. The authors emphasize both the potential and limitations of using the SAW method in the context of decision-making systems in robotics. The SAW method, known for its straightforward approach, was used to evaluate alternatives based on criteria such as sensor accuracy, energy efficiency, task turnaround time, safety, and adaptability. Each criterion was assigned a weight reflecting its significance. The alternatives, which represented different trajectories of solutions for the robotic system, were evaluated using weighted criteria.

The work [13] describes an approach for an integrated robotic system capable of explaining its decisions and beliefs, in particular the results of hypothetical actions. The authors proposed a robot architecture that was tested in the context of scene recognition and task planning, using both simulated and real images from a physical robot. The experimental results show the system's ability to reliably collect and combine new information, make decisions using the deep learning method, and provide accurate explanations.

The robot [14] offers a new approach to robotic decision-making that combines artificial intelligence (AI) planning and human interaction to solve problems effectively. The robot executes the plan in stages, and in the event that there are no certain operations to complete the task, it turns to the person to receive the next action. This approach allows for the automatic generation of missing planning operators based on observed state changes, estimating the probability of various alternative causations under conditions of high uncertainty due to the small number of samples. The authors compare this method with previous approaches, showing its advantages in fast learning without the need for offline learning and a lot of prior knowledge.

The work [15] is devoted to the structure of the Aczel-Alsina (AA) and Bonferroni mean (BM) operators for solving the problem of multicriteria group decision-making (MCGDM) in the environment of interval intuitionistic fuzzy numbers (IVIF). The proposed method allows you to evaluate the relationships between the different criteria when choosing the most suitable robot for a specific industrial task, taking into account factors such as the production environment, product design, production system and costs.

The work [16] examines the use of basic models, pre-trained on large and diverse data, for decision-making in real conditions. As these models actively interact with other agents, for example through dialogue with humans or autonomous navigation, they open up new perspectives for the development of systems of long-term understanding and interaction in various fields, such as dialogue, autonomous driving, healthcare, education and robotics. The article analyzes modern approaches to the application of basic models in practical decision-making tasks, using methods such as hints, generative modeling with conditions, planning, optimal management and reinforcement learning. The authors also discuss existing challenges and open questions in this area.

The study [17] presents in great detail the existing algorithms and methods of decision-making. The authors consider the meaning and principles of accurate methods of solving problems: Markov decision-making processes; policy evaluation; value functions; iterations of policies and values; linear programming. Thus, approximate value functions are described, which include: parametric representations; Nearest neighbor methods; Kernel smoothing; linear interpolation; regression methods (linear, neural network).

Therefore, research in the field of decision support systems in robotics is actively developing, since autonomous robotic systems require effective mechanisms for analyzing data and choosing optimal actions for performing tasks.

The scientific literature highlights various approaches to the construction of DSS, including algorithmic methods, machine learning, fuzzy logic, and expert systems.

In addition, the latest approaches to robot planning with the help of artificial intelligence and human integration are discussed, which allows for the rapid generation of missing operations and improved learning processes. In particular, the focus is on the use of basic models for real-world decision-making, which allows for a significant improvement in the interaction of robots with other agents and humans, expanding the possibilities of applying such systems in various industries, from autonomous driving to healthcare.

3 DISCUSSION

3.1 PRINCIPLES OF DECISION SUPPORT SYSTEMS IN ROBOTICS.

In the world of robotics, decision support systems are transforming into a critical tool for ensuring the autonomous operation of technical systems.

The evolution of modern DSS is characterized by a unique synthesis of traditional algorithmic methodologies, intelligent artificial intelligence technologies and advanced machine learning techniques, which creates a powerful mechanism for increasing the effectiveness and flexibility of decision-making processes.

Despite significant advances in the development of robotic systems, scientists and researchers continue to face a number of complex scientific and technological challenges that require in-depth study and development of innovative approaches.

The multidisciplinary nature of the problems necessitates constant improvement of the methodological base and the search for non-standard solutions in the field of intelligent robotic systems.

DSS in robotics are based on fundamental principles that ensure the efficiency, reliability and adaptability of robotic systems. Let us consider the key principles of construction and operation of such systems (Fig. 1).

1. The principle of hierarchy and multi-level means that the DSS must have a clear hierarchical structure that allows decision-making at different levels:
- strategic level – long-term planning and determination of global goals for the functioning of the robotic system;
- tactical level – operation of intermediate tasks, allocation of resources and adaptation to current environmental conditions;
- operational level – instant response to external stimuli, decision-making in real time.

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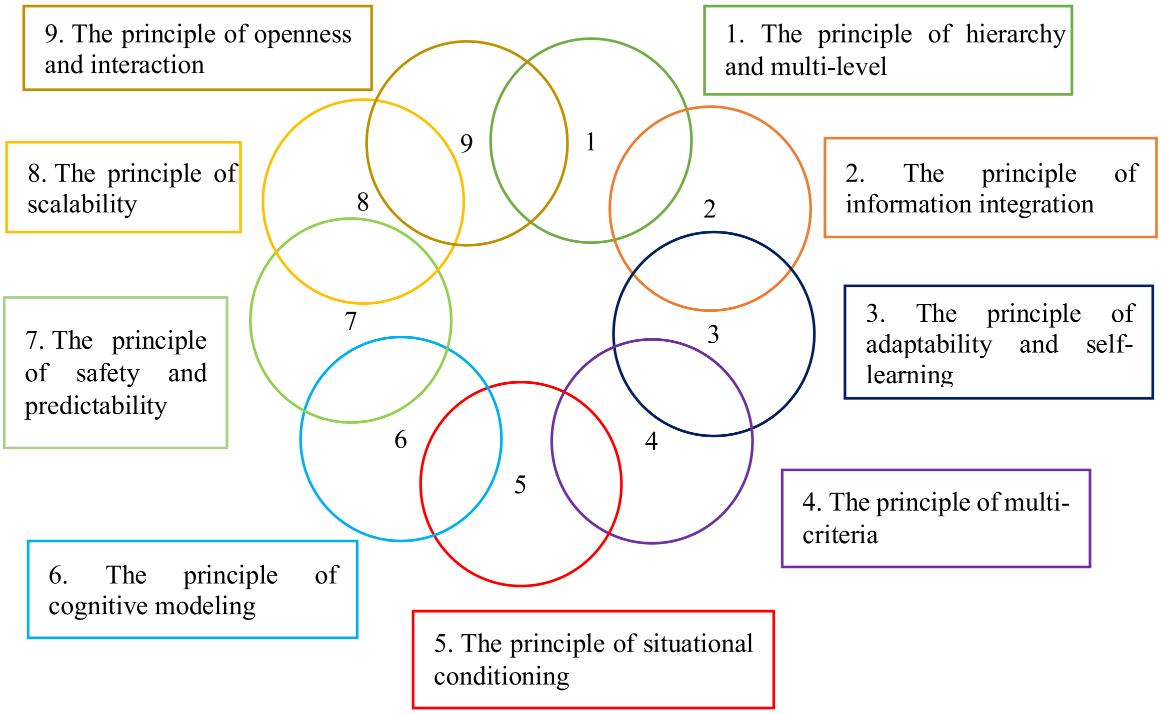

Figure 1. Key principles of DSS construction in robotics

2. The principle of information integration, because the effectiveness of the DSS is determined by the ability to accumulate and process information from various sources:
- sensor data from different types of sensors;
- accumulated experience in previous operations;
- knowledge bases and expert systems;
- external information sources.

3. The principle of adaptability and self-learning, since modern DSS should have the following mechanisms:
- continuous improvement of decision-making algorithms;
- correction of parameters based on the experience gained;
- the ability to self-learn and reconfigure.

4. The principle of multi-criteria is the way decision-making is carried out taking into account a set of interrelated criteria:
- the effectiveness of the task;
- energy consumption and safety;
- accuracy and reliability;
- economic feasibility.

5. The principle of situational conditionality, since the DSS should ensure:
- contextual adaptation of decisions;
- taking into account the specifics of the current situation;
- flexibility in choosing a strategy of action.

6. The principle of cognitive modeling, ideally, the use of the following methods:
- artificial intelligence;

- neural networks;
- fuzzy logic;
- evolutionary modeling.

7. The principle of safety and predictability, which will cover mandatory requirements:
- minimization of risks;
- forecasting possible consequences;

- the presence of emergency stop mechanisms;
- compliance with ethical standards of interaction with a person.

8. The principle of scalability, because the DSS must provide:
- the ability to increase functionality;
- adaptation to different types of robotic systems;
- easy integration of new modules and components.

9. The principle of openness and interaction, which includes:
- compatibility with external systems;
- ability to exchange data;
- integration into a single information space.

Adherence to these principles will allow the creation of highly intelligent, reliable and effective decision support systems in robotics, capable of functioning in complex, dynamic environments.

3.2 ALGORITHMS IN DECISION SUPPORT SYSTEMS IN ROBOTICS

Algorithms of decision support systems in robotics constitute a complex and multi-layered architecture of computational methods aimed at ensuring the efficient and autonomous functioning of robotic systems.

Modern algorithmic approaches can be classified into several key areas:
- artificial intelligence algorithms that provide robotic systems with the ability to analyze data, make decisions in conditions of uncertainty, and adapt to dynamic environments. For example, neural networks, support vector machines, evolutionary algorithms, fuzzy logic algorithms;

- machine learning algorithms that ensure the accumulation and transformation of experience by: learning with or without a teacher; reinforcement learning. For example, cluster analysis, regression models, deep learning, and Q-learning.

Let us consider the features of key algorithms used in decision support systems in robotics (Table 1).

Table 1. Comparison of algorithms of decision support systems

Algorithm	Essence	Advantages	Disadvantages	Application example
Q-learning	Reinforcement learning method to find the optimal strategy in an unknown environment.	- the ability to study without a teacher; - efficiency in complex dynamic environments.	- high computational complexity; - slow convergence; - difficulty in determining the reward.	- navigation of autonomous robots; - control of manipulators; - planning the trajectory of movement.
Neural networks	A computing system with a biologically inspired architecture for recognizing complex patterns.	- ability to generalize; - parallel information processing; - adaptability.	- require large amounts of data; - "Black box" principle; - high resource intensity.	- computer vision; - object recognition; - classification of obstacles.
Markov decision-making processes	Mathematical apparatus for modeling the sequence of states and transitions.	- accurate mathematical modeling; - taking into account uncertainty; - the ability to predict.	- complexity for systems with a large number of states; - linearity of the model; - sensitivity to initial conditions.	- planning the movement of robots; - control of manipulators; - logistics systems.

Continuation of Table 1.

Algorithm	Essence	Advantages	Disadvantages	Application example
Genetic algorithms	An evolutionary optimization method based on the mechanisms of natural selection.	- global search for a solution; - independence from the type of task; - parallelism.	- high computational complexity; - probabilistic nature of the result; - dependence on initialization parameters.	- optimization of trajectories; - allocation of resources; - design of robotic systems.
Fuzzy logic	Mathematical apparatus for working with imprecise and approximate reasoning.	- work with linguistic variables; - taking into account expert knowledge; - resistance to uncertainty.	- subjectivity in determining the rules; - complexity of formalization; - interpretation.	- adaptive robot control systems in unstructured environments (e.g., obstacle avoidance, speed control based on fuzzy sensor data); - control of robotic manipulators, taking into account inaccuracies; - building intelligent systems for household robots (for example, robot vacuum cleaners with an adaptive cleaning algorithm).
Bayesian networks	Probabilistic graphical model to represent cause-and-effect relationships.	- taking into account uncertainty; - visual presentation of knowledge; - the possibility of learning.	- complexity of construction; - sensitivity to data quality; - structure restrictions.	- predicting behavior; - diagnostics of systems; - risk assessment.

Table 1 demonstrates the main algorithmic approaches in decision support systems for robotics, their characteristics and application features.

Let's consider how the described algorithms work, which will provide the basis for their practical application in robotics.

1. Q-Learning is a reinforcement learning algorithm that is used to find the optimal strategy of action in an environment with unknown transitions. The main idea is to update the Q-function, which estimates the expected gain for each state-action pair. Q-function update formula:

$$Q(s_t,a_t) \leftarrow Q(s_t,a_t) + \alpha[r_{t+1} + \gamma \max_a Q(s_{t+1},a_t) - Q(s_t,a_t)], \quad (1)$$

where $Q(s_t,a_t)$ – the current value of the Q-function for the state s_t and the action a_t;
α – learning rate, which determines how quickly the Q-function is updated;
r_{t+1} – the reward received after performing the action a_t in the state s_t;
γ – discount factor, which determines the importance of future rewards;
$\max_a Q(s_{t+1},a_t)$ – the maximum value of the Q-function for the next state s_{t+1}.

Let's consider an example – navigating a robot in a maze. The robot is in the state s_t (the current cell of the maze).

The robot selects the action a_t (movement in a certain direction), and after performing the action, the robot enters the state s_{t+1} and receives a reward r_{t+1} (for example, +1 for reaching a goal, -1 for colliding with a wall). Then, the Q-function is updated by formula (1).

The modifications are:
- Deep Q-learning (DQN), which uses neural networks to approximate Q-function, which allows you to work with large state spaces;
- Double Q-learning, which uses two Q-functions to reduce the overestimation of values that often occurs in classical Q-learning;
- Prioritized Experience Replay, here the experience sample is prioritized for more effective learning.

2. Next, we will give a mathematical model of algorithms based on Neural Networks. Neural networks are made up of layers of neurons that compute output values based on inputs. Each neuron performs an operation:

$$y = f(\sum_{i=1}^{n} w_i x_i + b), \tag{2}$$

where x_i – input data;
w_i – weighting factors;
b – bias;
f – activation function (e.g. ReLU, sigmoid, tanh).

Let's consider an example of using neural networks for object recognition. Let the input data (images) be fed to the input layer. Data passes through hidden layers where it is processed. At the output, we get the probabilities of belonging to certain classes (for example, "car", "pedestrian").

The modifications are:
- convolutional neural networks (CNNs), which are used for image processing. They include convolutional layers to detect local features;
- recurrent neural networks (RNNs), which are used to process data sequences (e.g., text, time series);
- transformers, which use attention mechanisms to process data with long dependencies.

3. Markov Decision Processes (MDP). Mathematical model for decision-making in a random transition environment. It includes:

- the set of states S;
- the set of actions A;
- transition function $P(s_{t+1} | s_t, a_t)$,, which determines the probability of transition to the state s_{t+1} after performing the action a_t in the state s_t;
- the reward function $R(s_t, a_t)$, which determines the reward for performing the action a_t in the state s_t.

Consider an example of planning the movement of a robot. The robot is in the state s_t (current position). It chooses the action a_t (movement in a certain direction). According to the transition function, the robot enters a new state s_{t+1}. Receives the reward $R(s_t, a_t)$.

The modifications are:
- partially observable MDPs (POMDP) – used when the state of the medium is not fully observable;
- hierarchical MDPs – allow you to model complex systems with many levels of abstraction.

4. Genetic algorithms are based on the principles of natural selection. They include:
- population – a set of solutions (chromosomes) that represent possible options for solving the problem;
- fitness function, which determines the quality of each solution;
- operators – selection, crossover and mutation.

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Consider an example of optimizing the trajectory of a robot. At the beginning, the initial population of trajectories is generated. Each trajectory is estimated using an adaptability function (e.g., minimizing travel time). The best trajectories combine (cross) and undergo mutations. The process is repeated until an optimal solution is reached.

The modifications are:
- NSGA-II (Non-dominated Sorting Genetic Algorithm), which is used for multi-criteria optimization;
- genetic programming, which is used to optimize programs or rules.

5. Fuzzy Logic, which allows you to work with inaccurate data using fuzzy sets. Each variable has a membership function $\mu(x)$, which determines the degree of its belonging to a certain set.

Consider an example of a robot speed control system. Input data (e.g., distance to an obstacle) is converted to fuzzy sets. Fuzzy rules apply (for example, "if the distance is small, then reduce the speed"). Defuzzification is performed to obtain a clear value (for example, a specific speed).

The modifications are:
- adaptive fuzzy systems that use learning algorithms to automatically adjust rules;
- hybrid systems combine fuzzy logic with neural networks or genetic algorithms.

6. Bayesian Networks are probabilistic graphs that model cause-and-effect relationships between variables. They are based on Bayes' theorem:

$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}, \tag{3}$$

where $P(A|B)$ – posteriori probability of event A under the condition of event B;

$P(B|A)$ – plausibility of event B provided event A;
$P(A)$ and $P(B)$ – priori probabilities of events A and B.

Consider an example of diagnosing robot malfunctions. Let the possible causes of malfunctions be determined (for example, sensor failure, mechanical failure). Based on observations (e.g. sensor errors), the probabilities of each cause are estimated. Diagnostics are performed based on the most likely causes.

The modifications are:
- dynamic Bayesian networks, which are used to model systems that change over time;
- hybrid Bayesian networks that combine discrete and continuous variables.

Therefore, algorithms of decision support systems in robotics play a key role in ensuring the autonomy, adaptability, and efficiency of robotic systems. They allow robots to function in conditions of uncertainty, dynamic environments and complex tasks that require fast and accurate decision-making.

The main advantages of using these algorithms include:
- autonomy, because robotic systems can independently make decisions based on the data obtained, which allows them to work without constant human intervention;

- adaptability because algorithms such as Q-learning, neural networks and fuzzy logic allow robots to adapt to changes in the environment and new conditions;

- optimization, since genetic algorithms and Bayesian networks help to find optimal solutions in complex problems, such as trajectory planning, resource allocation or system diagnostics;

- uncertainty processing, because Markov processes and fuzzy logic allow you to work with inaccurate data and uncertainty, which is critical in real conditions;

- speed and efficiency – thanks to parallel data processing (e.g. in neural networks) and efficient training methods (e.g. Q-learning), robotic systems can quickly respond to changes and perform tasks with high precision.

The use of algorithms in decision support systems for robotics is critical because it provides a significant improvement in the performance of robotic systems. Thanks to these algorithms, robots can perform tasks

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faster and with less resource consumption, which makes them more efficient in industrial, scientific and domestic environments. For example, optimization algorithms allow you to minimize the time of operations or energy consumption, which is especially important in industry or when working with limited resources.

Additionally, algorithms help reduce the risks associated with working in challenging or hazardous environments. In industrial environments, space missions, or emergencies, robotic systems must make decisions in the face of uncertainty and dynamic change. Algorithms such as Markov processes or Bayesian networks allow robots to avoid errors that can lead to accidents, failures, or dangerous situations. This ensures not only security, but also the stability of the systems.

Another key aspect is the empowerment of robotic systems. Thanks to artificial intelligence and machine learning algorithms, robots are able to perform tasks that were previously inaccessible due to their complexity or the need for instant decision-making. For example, autonomous robots can navigate complex environments, recognize objects, or plan their actions in real time, opening up new possibilities for their applications in medicine, logistics, research, and more.

It is also important to ensure the intelligent interaction of robots with people and other systems. Artificial intelligence algorithms, such as neural networks or fuzzy logic, allow robots to interpret data, adapt to changes in the environment, and interact in a more natural and efficient way. This is especially important in settings where robots work together with humans, such as in the service industry, medicine, or education.

Thus, the use of algorithms in robotics not only increases the efficiency and safety of robotic systems, but also opens up new horizons for their application, making them indispensable in the modern world.

3.3 PROSPECTS FOR THE DEVELOPMENT OF DECISION SUPPORT SYSTEMS IN ROBOTICS

Decision support systems in robotics are a key component of autonomous and semi-autonomous robotic systems.

One of the promising areas for the development of DSS in robotics is the use of deep learning and neural networks. This makes it possible to analyze complex dynamic environments, process large amounts of data in real time, recognize objects and predict their behavior. Also, neural networks allow you to effectively learn based on past decisions and adapt behavior in accordance with changes in the environment.

Another important area is to increase the level of autonomy of robotic systems through reinforcement learning. The use of Q-learning algorithms and deep Q-networks allows robots to independently find optimal behavioral strategies, adapt to new conditions without prior programming, and minimize the risks of wrong decisions in critical situations.
Integration with cloud technologies opens up new opportunities for DSS, as it allows for rapid data exchange and analysis between a large number of robotic agents. This facilitates the use of centralized machine learning models, as well as enables remote control and monitoring of robotic systems.

Another promising area is the use of quantum computing, which can significantly speed up calculations for complex navigation problems, provide more efficient management of multi-level systems with a large number of parameters, and improve the resilience of the DSS to unpredictable changes in the environment.

Bioinspired approaches, such as neuromorphic computation, swarm algorithms, and adaptive learning based on evolutionary algorithms, are contributing to the development of more flexible behavior models for robotic systems. Focusing on biological principles allows you to create robots that are able to make decisions quickly in conditions of uncertainty and changing environments.

The combination of deep learning, reinforcement learning, cloud computing, quantum technologies, and bioinspired approaches is creating the conditions for significant advances in autonomous robotics.

3.4 RESEARCH RESULTS

The study of decision support systems in robotics revealed the fundamental importance of nine key principles of DSS construction, among which hierarchy and multi-leveling, information integration, adaptability and self-learning, multi-criteria, situational conditioning, cognitive modeling, safety and predictability, scalability, openness and interaction play a special role.

The study of the algorithmic component of DSS demonstrated the effectiveness of using six main types of algorithms: Q-learning, neural networks, Markov decision-making processes, genetic algorithms, fuzzy logic, and Bayesian networks. Each of these algorithms has its own advantages and limitations, making them the most effective for specific types of tasks in robotics.

In the course of the analysis, it was confirmed that the use of algorithms in the DSS provides five key advantages: autonomy of robotic systems, their adaptability to environmental changes, process optimization, efficient handling of uncertainty, as well as increased speed and efficiency.

The study revealed the prospects for the development of DSS in the direction of using deep learning and neural networks, which allows you to effectively analyze complex dynamic environments and process large data sets in real time. Integration with cloud technologies also has significant potential, which opens up opportunities for rapid data exchange and analysis between a large number of robotic agents.

Particular attention was paid to the prospects of using quantum computing, which can significantly speed up calculations for complex navigation problems and provide more efficient management of multi-level systems. The importance of bioinspired approaches, such as neuromorphic computations, swarm algorithms, and adaptive learning based on evolutionary algorithms, has also been established, which contribute to the development of more flexible models of robotic systems behavior.

In the study, a comparison of the characteristics of the DSS algorithms was carried out, the results are presented in Fig. 2.

Evaluation of characteristics on a 100-point scale, where:
- adaptability – the ability of the algorithm to adapt to changes;
- speed – the speed of data processing and decision-making;
- complexity – the complexity of implementation and computational requirements.

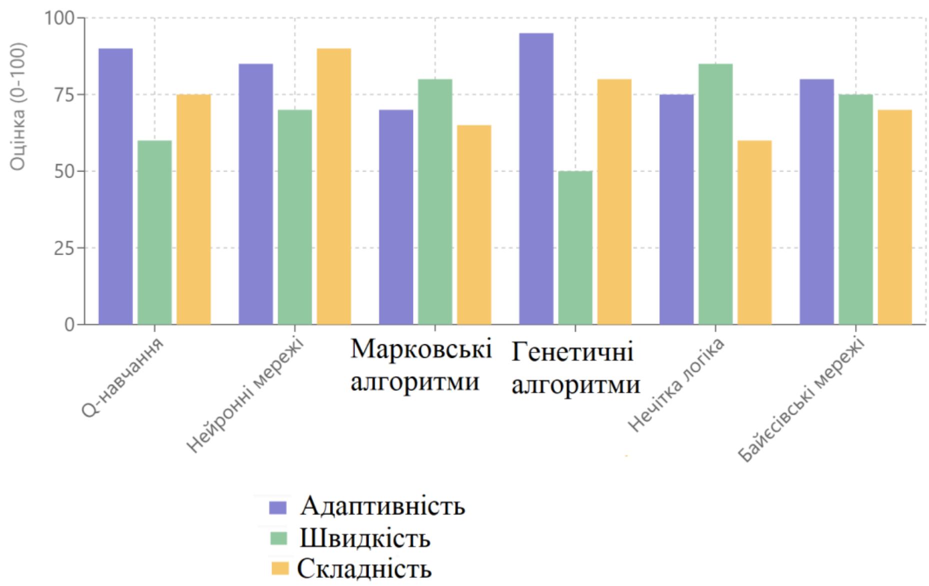

Figure 2. Comparison of the characteristics of the DSS algorithms

Based on Fig. 2, several important conclusions can be drawn regarding the comparison of different machine learning algorithms according to three parameters – adaptability, speed and complexity:

1. Genetic algorithms show the highest adaptability (about 95 %), but have a relatively low speed (about 50 %).

2. Q-learning shows a good balance of adaptability (about 85 %), but has a lower speed and medium difficulty.
3. Neural networks show balanced indicators in all three parameters, with high complexity of implementation.
4. Markov algorithms have average adaptability indicators, but good speed of work.
5. Bayesian networks show the most balanced performance among all algorithms, with no obvious weaknesses.

Thus, the results of the study confirm that the use of algorithms in robotics not only increases the efficiency and safety of robotic systems, but also opens up new opportunities for their application in various fields, including medicine, logistics, industry, and research. The combination of different technologies and approaches creates prerequisites for the further development of autonomous robotics and the expansion of its applications.

4. CONCLUSION

In the presented study, a comprehensive analysis of modern decision support systems in the field of robotics, which is important for the development of autonomous robotic systems, was carried out.

The main value of the work lies in the systematization and detailed study of the principles of construction of the DSS, which allows you to create more efficient and reliable robotic systems.

An important achievement of the study was the in-depth study of the algorithmic support of the DSS, including mathematical models and features of their practical application. This made it possible to identify the strengths and weaknesses of each approach and determine the optimal areas of their use in robotics.

The assessment of the effectiveness of various algorithms provided valuable data for choosing the most appropriate solution depending on specific tasks and operating conditions.

The study also outlined future directions for the industry, focusing on innovative technologies and approaches that can significantly expand the capabilities of robotic systems. Particular attention was paid to the potential of integrating modern artificial intelligence and cloud computing technologies with traditional robotics methods.

The results obtained are of significant practical value for developers of robotic systems, scientists and engineers, as they provide structured information on the principles of building effective DSS and the selection of optimal algorithmic solutions. This research creates a solid foundation for the further development of autonomous robotic systems and their implementation in various areas of human activity.

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