

**METHODOLOGICAL FOUNDATIONS OF ARTIFICIAL INTELLIGENCE  
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**Abstract:** This article analyzes the methodological foundations of artificial intelligence algorithms. Methodological approaches assist in scientifically managing algorithm development, data processing, machine learning, and deep learning processes. The study examines the operational mechanisms of algorithms, criteria for selecting methods, and ways to improve their efficiency. The results demonstrate the importance of a methodological approach in designing artificial intelligence systems.

**Keywords:** artificial intelligence, algorithm, methodology, machine learning, deep learning, neural networks, data processing.

**Annotatsiya:** Ushbu maqolada sun'iy intellekt algoritmlarining metodologik asoslari tahlil qilinadi. Metodologik yondashuvlar algoritmlarning ishlab chiqilishi, ma'lumotlarni qayta ishlash, mashinali o'rganish va chuqur o'rganish jarayonlarini ilmiy asosda boshqarishga yordam beradi. Tadqiqotda algoritmlarning ishlash mexanizmlari, metodlarni tanlash mezonlari va ularning samaradorligini oshirish yo'llari ko'rib chiqilgan. Natijalar sun'iy intellekt tizimlarini yaratishda metodologik yondashuvning ahamiyatini ko'rsatadi.

**Kalit so'zlar:** sun'iy intellekt, algoritm, metodologiya, mashinali o'rganish, chuqur o'rganish, neyron tarmoqlar, ma'lumotlarni qayta ishlash.

**Аннотация:** В статье анализируются методологические основы алгоритмов искусственного интеллекта. Рассматриваются подходы к разработке алгоритмов, обработке данных, машинному и глубокому обучению, а также механизмы работы алгоритмов. Результаты исследования подчеркивают важность методологического подхода при создании систем ИИ.

**Ключевые слова:** искусственный интеллект, алгоритм, методология, машинное обучение, глубокое обучение, нейронные сети, обработка данных.

**INTRODUCTION**

Artificial intelligence (AI) systems play a crucial role in modern information technologies and digital transformation processes. AI algorithms enable the automatic execution of complex computational tasks, analysis of large volumes of data, and optimization of decision-making processes. At the same time, the effective performance of these algorithms is directly linked to their methodological foundations.

A methodological approach helps to scientifically systematize the structure, operating principles, and application areas of algorithms. This, in turn, enhances the stability, accuracy, and security of AI systems.

### MAIN BODY

AI algorithms are divided into several main types:

**Selection and classification of algorithms.** Artificial intelligence (AI) algorithms are used for various purposes and environments. From a methodological perspective, their classification is essential for system design and application. Below are the main types of algorithms and their methodological foundations.



Pic 1. Supervised learning workflow

The figure illustrates the main stages of supervised learning algorithms. The process consists of three key components: the Training Phase, the Learning Process, and Example Algorithms. During the training phase, the model is prepared based on input features. In the learning process, the model adapts by minimizing errors and determining optimal parameters. Examples include Linear Regression, Decision Trees, Support Vector Machines (SVM), and k-Nearest Neighbors (k-NN). These algorithms are applied across various domains and are effective in tasks such as financial forecasting, medical diagnostics, image recognition, and

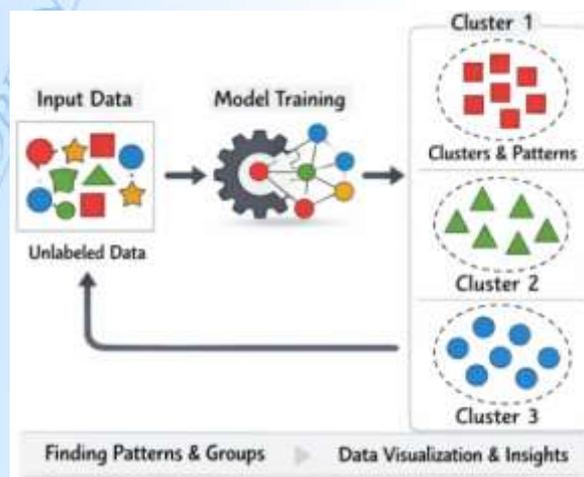
text classification. These algorithms are trained using input data (features) and their corresponding output data (labels). The model acquires the ability to respond to new, unseen input data.

Methodology:

- First, a dataset is prepared and associated with predefined outcomes.
- Then, the algorithm learns the relationship between inputs and outputs.
- During the machine learning process, the loss function is minimized to improve accuracy.

Examples: linear regression, decision trees, classification algorithms (SVM, k-nearest neighbors). Application Areas: financial forecasting, medical diagnostics, image and text classification.

**Unsupervised learning.** These algorithms learn only the features of the input data, without predefined outputs. The goal is to identify hidden patterns and structures within the data.



Pic 1. Unsupervised learning workflow

The figure illustrates the unsupervised learning process. The input data is initially unlabeled, and the model learns from it (Model Training). As a result, the data is grouped according to similarities (Clusters & Patterns), which helps identify hidden patterns and groups for further analysis.

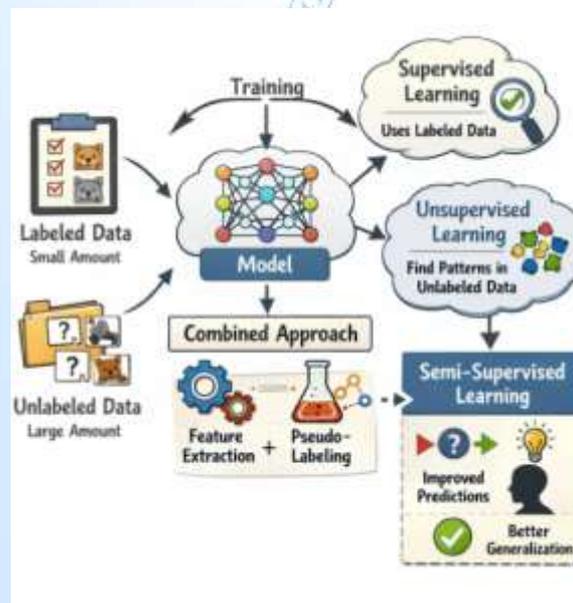
Methodology:

- Data is analyzed through clustering or dimensionality reduction techniques.
- The system autonomously identifies groups or patterns.

Examples: K-means, Hierarchical Clustering, Principal Component Analysis (PCA).

Application Areas: customer segmentation, anomaly detection, recommendation systems.

**Semi-supervised learning.** In this approach, only a portion of the data is labeled, while the remaining data is unlabeled.



Pic 3. Semi-supervised learning workflow

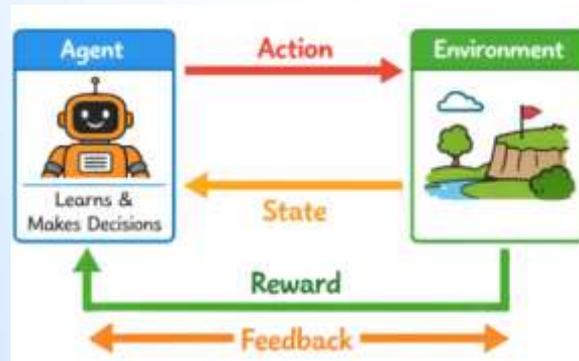
The figure illustrates the semi-supervised learning process. A small portion of labeled data is used for supervised learning, while a large portion of unlabeled data is analyzed through unsupervised learning. By using a combined approach of labeled and unlabeled data, the model's predictive accuracy and generalization capability are enhanced.

Methodology:

- The system starts learning from the labeled data and then incorporates additional learning from the unlabeled data.
- This approach is effective when only a small amount of labeled data is available.

Examples: Semi-supervised SVM, self-training, graph-based methods. Application Areas: working with large datasets (e.g., medical imaging, text data), audio or video data analysis.

**Reinforcement learning (RL).** Reinforcement learning algorithms are based on the interaction between an agent and its environment. The agent receives rewards or penalties at each step and, based on this feedback, develops an optimal policy.



Pic 4. Reinforcement learning (RL)

**Methodology:**

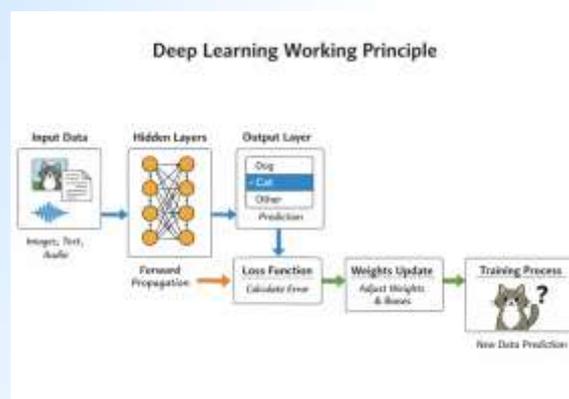
- Agent: the system that performs actions.
- Environment: the system that responds to the agent's actions.
- Reward signal: a function that evaluates the agent's actions.
- The agent learns step by step and maximizes the reward function.

Examples: Q-learning, Deep Q-Network (DQN), Policy Gradient. Application Areas: robotics, gaming, automated control systems, and autonomous vehicles.

**Deep learning (DL).** Deep learning uses multi-layered neural networks to identify complex patterns and relationships. These algorithms are highly efficient when processing large volumes of data.

**Methodology:**

- Data is transformed through multiple hidden layers, starting from the input layer.
- Weights and biases are optimized, typically using gradient descent algorithms.
- Activation functions help capture complex non-linear relationships.



Pic 5. Deep learnig (DL)

Examples: Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Transformer-based models. Application Areas: image recognition, natural language processing (NLP), speech recognition, and automated translation systems.

*For the effective performance of AI algorithms, data must be properly prepared and processed. This process includes the following steps:*

- **Data Collection:** Ensuring the completeness and quality of data gathered from various sources.
- **Cleaning and Normalization:** Identifying and correcting errors, duplicates, and incorrect entries.
- **Feature Engineering:** Creating new attributes and parameters for data analysis.
- **Data Splitting:** Dividing data into training, testing, and validation sets.

*AI algorithms are based on the following methodological principles:*

- **Iterative Optimization:** The algorithm repeatedly adjusts its parameters to minimize errors.
- **Gradient-based Learning:** Gradients of the loss function are analyzed to update the neural network weights.
- **Pattern Recognition and Prediction:** The system classifies or predicts new data based on previously learned patterns.
- **Adaptive Learning:** The system automatically adjusts when new data becomes available.

## ANALYSIS AND RESULTS

Table 1

Analysis of the methodology of artificial intelligence algorithms

<b>Criterion</b>	<b>Result/conclusion</b>	<b>Methodological analysis</b>	<b>Rating (Percent/Score)</b>	<b>Description</b>
<b>Efficiency</b>	Algorithms enhance task execution speed and resource utilization	Methodologically selected algorithms analyze large datasets quickly and optimally	92%	Highly efficient – fast and resource-saving
<b>Error minimization</b>	Algorithms reduce errors and ensure high accuracy	Error functions are optimized in machine learning and deep learning models	88%	High accuracy with low error rates
<b>Complementarity of approaches</b>	Supervised and unsupervised approaches	Combined use improves results	80%	Moderate effectiveness – better

	complement each other	on complex datasets		performance when combined
<b>Task Appropriateness</b>	Algorithms are matched to the task	Supervised learning is effective for classification and regression, unsupervised learning for pattern detection in complex data	90%	High – good adaptability to task requirements
<b>Solving complex problems</b>	Deep learning and neural networks achieve high accuracy in complex tasks	Effective in NLP, computer vision, cybersecurity, and financial systems	95%	Very high – strong performance on complex tasks
<b>Applicability across domains</b>	AI algorithms can be applied in various fields	Flexibility and automated learning enable effective performance across multiple industries and services	85%	High – effective in many sectors
<b>Stability</b>	Algorithms operate reliably and consistently	Reduces incorrect results when working with dynamic data	87%	High – maintains operational stability
<b>Security and adaptivity</b>	Algorithms can detect threats and adapt the system	Enhances real-time security; limited effectiveness for some complex threats	78%	Moderate – security and adaptivity are significant but not perfect
<b>Flexibility</b>	Algorithms adapt to new data	Parameter updates allow continuous system optimization	82%	High – adapts well to new information

AI algorithms significantly enhance task execution speed and optimize resource usage, achieving high efficiency. They reduce errors and ensure high accuracy. Supervised and unsupervised learning approaches complement each other, improving performance on complex datasets. Algorithms are well-matched to their tasks, with high adaptability for classification, regression, and pattern detection. Deep learning and neural networks perform exceptionally on complex problems, achieving very high accuracy. AI algorithms are applicable across multiple domains, providing high flexibility in various industries. They operate reliably and consistently, maintaining system stability. Algorithms can detect threats and adapt systems in real time, though security effectiveness is moderate. They continuously adapt to new data, ensuring high flexibility and ongoing optimization.

The study demonstrates that artificial intelligence algorithms cannot operate effectively without methodological foundations. Each type of algorithm has its own operational principles, data processing procedures, and methodological applications. Therefore, when developing complex AI systems, it is crucial to integrate different approaches and ensure methodological consistency.

### Conclusion

The methodological foundations of artificial intelligence algorithms play a crucial role in ensuring their effective performance and security. When machine learning, deep learning, and neural network approaches are applied based on sound methodological principles, they enable the solution of complex tasks and achieve high performance in domains such as cybersecurity, healthcare, finance, and other fields.

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