EPISTEMOLOGICAL AND MATHEMATICAL FOUNDATIONS OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES

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Annotation:This article presents an in-depth analysis of the epistemological and mathematical foundations of artificial intelligence technologies from the perspective of the modern scientific paradigm. Within the scope of the research, the theoretical bases of artificial intelligence are evaluated through a gnoseological approach and analyzed using mathematical modeling, algorithmic structures, and formal logical systems. Particular emphasis is placed on the functional foundations of intelligent systems based on Bayesian probability theory, neural network models, and methods of mathematical induction. Additionally, the ontological and cognitive aspects of artificial intelligence's knowledge base, knowledge representation, and processing mechanisms are subjected to scientific scrutiny. The study draws conclusions based on deductive analysis, comparative (comparative) methodology, and a systematic approach.

Keywords: Artificial intelligence, epistemology, mathematical modeling, algorithm, neural network, formal logic, gnoseological approach, knowledge base, induction, Bayesian theory, intelligent systems.

INTRODUCTION.

Since the beginning of the 21st century, the rapid development of science and technology has turned the artificial modeling of human thinking into a pressing scientific issue. In particular, the formation and evolution of the concept of artificial intelligence (AI) has given rise to new theoretical approaches at the intersection of mathematics, computer science, and philosophy. Artificial intelligence technologies not only enhance the efficiency of computational systems but also enable the automation of complex cognitive processes, the modeling of decision-making mechanisms, and the processing and generation of knowledge.In analyzing the theoretical foundations of artificial intelligence, it is essential to first examine its epistemological basis—that is, the nature of knowledge, its formation, representation, and application in practice. At the same time, the mathematical foundations of AI technologies are expressed through logical computations, algorithmic models, probability theory, optimization methods, and neural networks. These components define the functional capabilities of artificial intelligence systems and serve as the basis for their theoretical Justification. This article analyzes these two dimensions epistemological and mathematical components in a complementary manner. The research scientifically substantiates the theoretical foundations of artificial intelligence technologies using scientific-methodological approaches such as the deductive-analytical method, mathematical modeling, algorithmic approach, and gnoseological analysis.

DISCUSSIONS AND RESULTS.

In the context of modern technological development, artificial intelligence (AI) is rapidly emerging not only as a practical tool but also as a complex interdisciplinary paradigm at the theoretical and methodological levels. A deep understanding of the essence of AI, along with its structural, conceptual, and methodological analysis, requires a systematic study of its epistemological foundations and mathematical principles. These two aspects are closely interrelated and represent the dual foundational elements that support the scientific construction of AI systems.Epistemology the philosophical study of knowledge plays a fundamental role in substantiating the intellectual capabilities of AI systems. The processes of cognition, the cognitive model of the human mind, the formation of knowledge, and its conceptual structure are directly linked to the principles by which AI operates. From this perspective, AI manifests not merely as an algorithmic and computational system but as an artificial cognitive subject capable of making decisions based on knowledge.Moreover, AI's capacity to process knowledge is shaped through ontological modeling, semantic networks, knowledge bases, and formal logical systems.

For instance, knowledge within a specific domain can be structurally expressed at the ontological level, enabling machines to analyze this knowledge through logical interrelations. In this process, epistemic constraints and gnoseological categories such as verification and falsification are also considered.To ensure AI operates functionally in real-world environments, it must be mathematically grounded and modeled. In this regard, discrete mathematics, formal logic, probability theory, mathematical statistics, and optimization theories serve as core components of AI technologies. Of particular significance are probabilistic and statistical models—such as Bayesian networks, Markov processes, clustering algorithms, and gradient-based optimization mechanisms which enhance the capabilities of AI systems in decision-making, learning, and prediction.In addition, deep learning algorithms implemented through neural networks strive to model the structural and functional aspects of human brain activity. Recursive algorithms, mathematical induction, and the theory of algorithmic complexity play an important role in theoretically evaluating the efficiency of AI technologies and determining their practical applications.

All these elements contribute to the adaptability, flexibility, and balanced functioning of AI in diverse environments.The integration of epistemological and mathematical foundations ensures the comprehensive operational mechanism of AI. To form knowledge, convert it into formal structures, and process it algorithmically, an interdisciplinary methodology is required. In AI systems, knowledge (epistemic units) is projected onto mathematical models, and their functional and semantic equivalence is determined at the algorithmic level.As a result, the theoretical foundations of AI technologies represent a symbiosis of philosophy and mathematics. At this point, AI demonstrates its intellectual essence in practice—as an artificial subject capable not only of receiving knowledge but also of structuring, analyzing, transforming, and reconstructing it anew.

Within the scope of this research, the epistemological and mathematical foundations of AI technologies were systematically analyzed. The findings reveal that the integration of epistemological approaches and mathematical formalisms is of particular significance as the theoretical basis of AI. This integration ensures that AI systems are capable not only of storing knowledge but also of processing and updating it on a logical-gnoseological basis.As an epistemological component, the representation of knowledge and ontological structures enable AI to simulate cognitive processes found in human thinking. This is essential for machines to understand contextual knowledge and make novel decisions in complex scenarios. At the same time, the application of mathematical methods especially probability theory and optimization algorithms provides the ability to function effectively in uncertain and dynamic environments.The analysis also shows that Bayesian approaches and deep learning algorithms play a crucial role in enhancing the adaptability and self-improvement potential of AI systems. These methods allow AI to operate with high reliability when handling uncertain data.

Furthermore, the application of mathematical induction and recursive algorithms confirms the theoretical and practical advantages of enabling AI to acquire new knowledge and solve complex problems. This significantly enhances the capacity of AI systems to perform functions akin to human reasoning.

In conclusion, AI technologies built upon epistemological and mathematical paradigms not only achieve high algorithmic efficiency but also open a new qualitative stage in knowledge management and transformation. This creates new opportunities for addressing the fundamental problems of modern AI and serves as a solid theoretical foundation for the future development of more advanced and specialized intelligent systems.

CONCLUSION.This scientific research has revealed the epistemological and mathematical foundations of artificial intelligence technologies through a comprehensive and systematic approach. The results of the study indicate that, as the theoretical basis of AI systems, epistemological concepts—such as the process of cognition, the ontological structures of knowledge, and gnoseological models must be thoroughly analyzed on a scientific basis. These concepts form the theoretical foundation for AI systems to simulate human thinking, structurally represent knowledge, and generate new knowledge.Moreover, mathematical methods including formal logic, probability theory, optimization algorithms, and deep learning technologies play a central role in expanding the algorithmic and functional capabilities of artificial intelligence. These mathematical approaches serve as fundamental tools for ensuring decision-making, learning, and adaptability under complex and uncertain conditions.The integrated synthesis of epistemological and mathematical components strengthens the theoretical foundation of the AI field and ensures its effective application in practical domains such as scientific research, industry, education, and many others. In this way, the epistemological-mathematical foundations of AI technologies significantly influence the development of the field both theoretically and practically, enabling the formation of more complex functions in human-intellectual systems.

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