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Research Article

Investigating the Fundamental Mathematical Logic Relationship and Driving Mode in Artificial Intelligence

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Abstract

Mathematics serves as the cornerstone for expressing the logic of macro-to-micro artificial intelligence. It provides a quantitative framework to describe cognition, emotion, and high-level intelligence. By delving into fundamental mathematics, we gain insight into the direct structure of correlation and causality in artificial intelligence. This understanding paves the way for novel data mining methods characterized by multi-modal, multi-center, and multi-scale approaches. Moreover, comprehending the driving modes of artificial intelligence within machine learning involves studying brain-inspired computing that mimics energy consumption and computing power. Additionally, large-scale simulation methods contribute to establishing mathematical logic relationships and driving modes in artificial intelligence. In essence, mathematics furnishes us with the foundational tools for developing new models in artificial intelligence. It offers a bedrock for mathematical thinking and acts as a guiding force in exploring the realms of AI-driven innovation.

Keywords: Basic Mathematics; Logic Relationship; Driving Mode; Artificial Intelligence

Introduction

With the rise of ChatGPT and the increasing complexity of AI models, mathematics has become the core foundation of artificial intelligence. The relationship between data and AI has become more significant, with mathematics playing a crucial role in modeling, data collection, data mining, and analyzing logical relationships within mathematical algorithms. As AI evolves, mathematics provides the essential framework for research and analysis in this field. “Mathematical Logic and Artificial Intelligence” by Peter H. Schmitt [1] is a book that explores the intersection of mathematical logic and artificial intelligence. It delves into topics such as propositional logic, predicate logic, and modal logic, examining their applications in the field of AI. “Logic and Artificial Intelligence” by Nils J. Nilsson [2] presents the theoretical foundations of the logical approach to artificial intelligence. The book highlights the use of logical languages for expressing declarative knowledge in AI systems and discusses the clear semantics provided by symbolic logic for knowledge representation. It also examines deductive inference techniques and addresses challenging problems in the field. “Mathematical Logic for Computer Science” by Mordechai Ben-Ari [3] is a comprehensive guide that focuses on using mathematical logic in computer science. The book covers semantic tableaux, which are sound and easy-to-understand tools for reasoning about logical formulas. The third edition includes new chapters on SAT solvers and model checking, with supplementary materials available for qualified instructors. “Artificial Intelligence: Foundations of Computational Agents” by David L. Poole and Alan K. Mackworth [4] provides an introduction to various aspects of artificial intelligence. The book explores foundational concepts, including knowledge representation, reasoning, planning, and decision-making in computational agents. “Logic in Computer Science: Modelling and

Reasoning About Systems" by Valentin Goranko [5] is a journal article that focuses on modeling and reasoning about systems using logic in computer science. It discusses various techniques such as model checking, formal verification, and inference methods applied to computer science problems. Mathematics is a formal science that explores the concepts of numbers, structures, and space. It involves abstract and logical reasoning, encompassing counting, calculation, measurement, and observation of object shape and movement. Mathematicians expand on these concepts, rigorously deriving theorems by formulating new conjectures and utilizing selected axioms and definitions. On one hand, mathematics serves as a foundation for artificial intelligence. To ensure stable and significant progress in AI, addressing fundamental mathematical problems is essential. On the other hand, the development of artificial intelligence also contributes to advancements in mathematics research. This reciprocal relationship plays a crucial role in fostering progress. Mathematical reasoning plays a central role in artificial intelligence (AI) and its various applications. Keren [6] highlights the importance of general intelligence in mathematical reasoning and proposes a theoretical framework for learning object representations. Fuzzy logic, with its ability to represent uncertainty, finds applications in AI systems, as demonstrated by Wang and Mendel's [7] work on fuzzy opinion networks. Additionally, Klement and Slany [8] discuss the innovative applications of fuzzy logic in AI, particularly focusing on fuzzy expert systems. The intersection between quantum mathematics and AI is explored by Widdows, Kitto, and Cohen [9], who emphasize the shared mathematical techniques between the two fields. Petrie [10] reflects on the foundations of AI from a retrospective perspective, acknowledging its mathematical underpinnings rooted in complexity theory and neural networks. Shikhman and Müller [11] discuss the importance of mathematical models in big data analytics, highlighting their application across various disciplines including economics, biology, linguistics, sociology, electrical engineering, computer science, and AI. Bachratá et al. [12] stress the significance of understanding mathematical concepts for effective problem-solving in informatics (Bachratá et al.). Overall, these studies underscore the essential role that mathematical foundations play in advancing AI research. Mathematics plays a central role in machine learning and artificial intelligence, addressing the intelligent agent's behavior and its interaction with the environment. It provides the foundation for simulating human-like abilities and enhancing problem-solving capabilities. Mathematics optimizes function spaces and parameter spaces in machine learning, serving as the cornerstone and essence of artificial intelligence. It establishes a standardized scientific framework, incorporating various mathematical theories such as logic, probability, computing, fuzzy set theory, chaos theory, and more. Mathematical thinking is crucial for calculations in artificial intelligence, including mathematical modeling, probability theory, optimization theory, and mathematical statistics. The future application of artificial intelligence in computer science relies on mathematical computing perspectives. Unified mathematical principles underlie different machine problems and their connection to the mathematical foundation of Artificial General Intelligence (AGI). These insights validate the relationship between artificial intelligence, mathematics, and computer science. Mathematical reasoning is essential in AI and its applications. It encompasses general intelligence, fuzzy logic for handling uncertainty, shared techniques with quantum mathematics, and mathematical underpinnings from complexity theory and neural networks. Mathematical models are crucial in big data analytics across multiple disciplines. Understanding math concepts is emphasized for effective problem-solving in informatics, highlighting the inseparable relationship between AI and foundational mathematics.

The logical relationship between artificial intelligence and basic mathematics

The relationship between artificial intelligence and basic mathematics is very close. As the most basic discipline, mathematics needs to understand the following issues in order to cooperate with the development of artificial intelligence.

1) The fundamental principles of statistics revolve around the essence of experience, which involves the process of induction and summarization based on past events. Statistics serves as the core thinking mode for such summarization and induction. Academic datasets, often presented as seemingly chaotic numbers, require reclassification, analysis, and the application of statistical scientific rules and methods to unveil meaningful patterns and results. These statistical rules and methods provide insights that can be comprehended by humans. Statistics forms the bedrock for artificial intelligence's ability to learn from vast amounts of data, also known as big data. While statistical methods are powerful, they alone cannot encompass all aspects of analyzing and summarizing experiences. This is where artificial intelligence comes into play, employing various techniques to further enhance the process of extracting valuable insights from diverse types of data. Underlying these concepts is basic mathematics-the source from which statistics derives its foundation. Basic mathematics encompasses areas such as numerical operations, group theory, diagrams, and set theory. By leveraging these mathematical concepts, the technological aspect of statistics becomes more pronounced in unlocking knowledge from data Figure 1.

2) Within the realm of mathematics, different theories contribute to the development and functionality of artificial intelligence. Firstly, logic provides the framework for reasoning in artificial intelligence systems. It establishes the rules and principles that govern the behavior and decision-making processes of these systems. Group theory, on the other hand, offers a set of mathematical methods and techniques that are particularly useful in artificial intelligence. These methods enable the manipulation and analysis of complex data structures, allowing for efficient problem-solving and optimization algorithms. Graph theory plays a crucial role in describing and representing various aspects of artificial intelligence. It provides a powerful tool for modeling relationships and connections between different entities or data points,

facilitating tasks such as network analysis or pattern recognition. Lastly, set theory forms the basis for constructing multi-dimensional mathematical spaces that are essential in artificial intelligence applications. These spaces enable the representation and analysis of data in multiple dimensions, allowing for more comprehensive understanding and interpretation. In terms of mathematics as a whole, it provides both logic and algorithms to address different problems. The logical foundation serves as a basis for tackling various challenges, while algorithms provide implementations to solve specific phenomena or tasks. Topological relationships embedded within algorithms form an essential component of basic mathematics, aiding in solving problems efficiently. Artificial intelligence relies on big data to accomplish two primary types of tasks. Firstly, it utilizes data logic to complete projects such as clustering, factor analysis, and regression models. Secondly, it involves mapping inputs to output results across various elements within massive datasets—a process crucial for achieving desired outcomes in artificial intelligence applications. Basic mathematics provides geometry, triangle, differential geometry, and topology and measurement theory for artificial intelligence. It can be seen that these visible logics reproduce the relationship between data and provide researchers with the entrance to the data that can operate the data Figure 2.

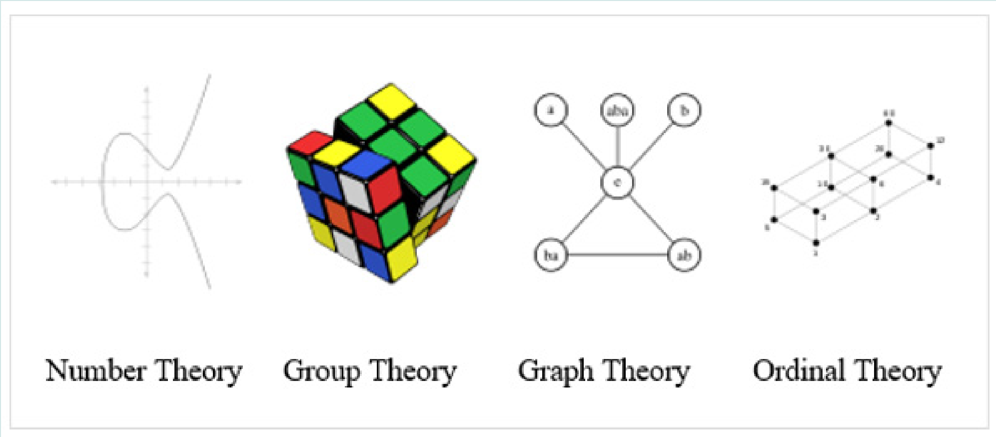

Figure 1: Mathematical foundation.

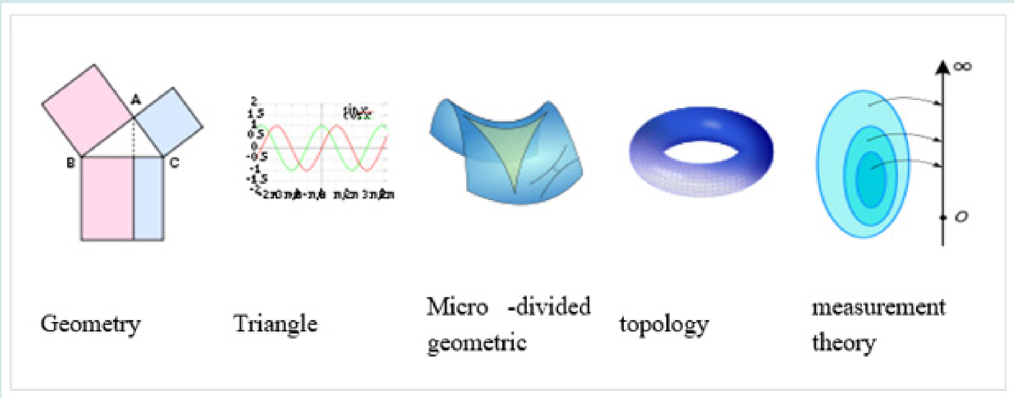

Figure 2: Basic mathematical classification.

3) The principles of basic mathematics have mentioned a structural interpretation mechanism for artificial intelligence. In many cases, artificial intelligence cannot describe the process mechanism through its own logic, but is there a particularly good way? This is also a scholar research. The focus of these issues can be well supported in terms of basic mathematics principles. Basic mathematics can combine data logic processes in artificial intelligence through calculus, vector analysis, micro -division equation, dynamics, chaos, etc. The angle gives an interpretation of another way, and the basis for each other can solve the problems in the field of artificial intelligence small data well and provide a good way to open up new mathematical application artificial intelligence. Basic mathematics provides calculus, vector, differential equation, dynamics, chaos, and replica analysis methods for artificial intelligence's data logic interpretation. By supporting mutual support logic processes, phenomenon to phenomenon is increased to the level of data logic explanation, providing researchers with thinking paths and methods of solving problems. In terms of

supporting deep learning, puppet learning, and migration models, basic mathematics requires modeling analysis in the thinking scope of basic mathematics. Basic mathematics is the foundation of many artificial intelligence models. The network architecture of artificial intelligence and the foundation of network analysis comes from Logic with basic mathematics thinking Figure 3. The basic thoughts of basic mathematics in artificial intelligence modeling and functional space are the requirements for data universality, promotion, and learning in artificial intelligence. Basic mathematics provides the necessary learning methodology or functional space in functional space in basic mathematics. Learning theory. It is generally believed that in the face of the basic problems of artificial intelligence, its cornerstone lies in mathematics.

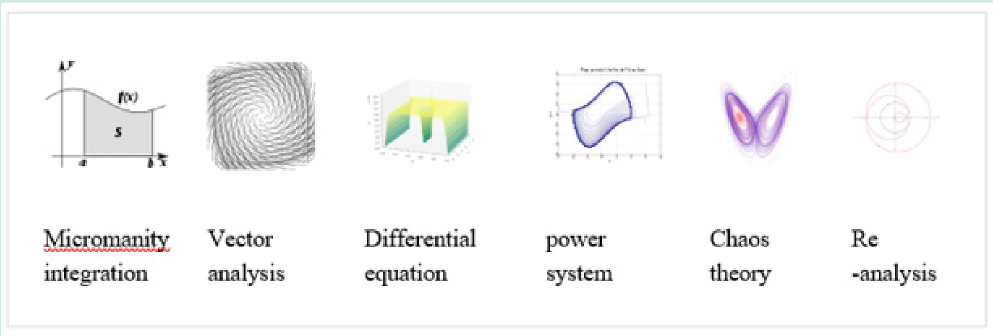

Figure 3: Basic mathematical analysis method.

The driving principle of basic mathematics to Artificial Intelligence

The fundamental role of mathematics in artificial intelligence is self-evident. Moreover, artificial intelligence technology brings a fresh perspective to mathematical research and has revolutionary impacts. Academician Xu Zongben [13] conducts a profound analysis based on the optimization of artificial intelligence and the fundamental mathematical requirements of PDE problems. Formalization is indispensable for programming and computerization. Modelization is crucial for quantitative analysis and intellectualization. Science ensures the systematic approach and modernization of research endeavors. This concise summary enhances the scholarly reading experience.

The optimization of basic mathematics has been promoted by artificial intelligence:

The Optimization is the basic problem of mathematics. It has been thoroughly studied in local optimization, and the field of optimization is very difficult. It is precisely because of the application of artificial intelligence on optimization issues, which brings dawn to the global optimization. Optimization is the basic mathematical issue. The logic of artificial intelligence brings a good driving role to optimization Table 1.

Table 1: Mathematics and artificial intelligence can optimize logic.

1	Adaptability	The method of "Learn to Learn" first appeared in 2006, and then many technologies appeared in unpredictable. Essence	This method is to solve problems from the perspective of macro learning methodology.
2	Super parameter	Taking the problem of compression perception as an example, the following figure shows the basic framework of compression perception. In the formula, the first item is an analogy.	This method, especially in applications such as image processing and medical imaging, has achieved the best neural network models with the best performance.
3	Global optimization	The problem of global optimization has always been a problem, but if this problem is solved from the perspective of strengthening learning, its appearance will be refreshing.	For example, in the MNIST handwriting number recognition, to solve the problem of optimization of 7960 dimensions, you can use a full gradient descent method to optimize.

Basic mathematics plays a crucial role in modeling artificial intelligence:

particularly in the application of artificial intelligence to solve partial differential equation (PDE) problems. Academician Xu Zongben considers this application as a successful utilization of artificial intelligence in mathematics. The general form of a PDE is represented by the equations shown below. The first line depicts the relationships among the unknown functions, while the second line represents the initial conditions that these functions must satisfy. Combining these three equations forms a differential equation problem. Mathematicians have proposed various methods such as finite difference, finite element, and boundary element methods, which have achieved great success in solving PDEs. However, artificial intelligence offers a fresh perspective and alternative solutions to this problem by employing a sample space approach, specifically using integral methods for discrete differential equations. Within the framework of artificial intelligence, "intelligence" can be understood as discovering a suitable differential equation, and "environment" can be seen as the initial and boundary conditions provided by the aforementioned formulas. By adopting this methodology, neural networks can effectively approximate solutions to the differential equation.

Artificial intelligence and basic mathematics play a crucial supporting role in various aspects:

Merely relying on data is insufficient, just as having a fine model alone is inadequate. It is important to consider the decades of research conducted alongside the data. Models represent the refinement of data, enabling us to reduce our reliance on extensive datasets. However, it is worth noting that models also have limitations, and researchers often compensate for these limitations by using data. Significant progress has been made in different fields worldwide to address these challenges. For instance, the statistical community has achieved breakthroughs in researching high-dimensional, sparse, and distributed statistics. The exploration of deep learning's connection with differential equations has yielded important advancements. The machine learning industry continuously breaks assumptions and pioneers new learning paradigms. Additionally, substantial progress has been made in AI chip development. Nevertheless, it is essential to acknowledge that these advancements are still far from resolving the fundamental mathematical issues underlying artificial intelligence. Solving these core mathematical problems serves as the driving force behind future advancements in artificial intelligence and its cutting-edge domains.3.4 The driving force behind artificial intelligence algorithms lies in basic mathematics. These algorithms are primarily focused on analyzing and processing large amounts of data, addressing issues related to big data analysis and processing technology. The integration of mathematics and computer science has led to the development of intelligent technology and applications, with algorithms serving as the theoretical foundation. Big data analysis and processing involve tasks such as data processing, clustering, classification, regression, dimension reduction, and correlation analysis. These tasks rely on appropriate computer algorithms to be executed effectively. The core steps of AI algorithms often require solving fundamental mathematical problems in the context of big data. These algorithms are referred to as basic algorithms for big data computing. The absence of such algorithms is due to the fact that traditional computing theory and its associated algorithm design and analysis methods become ineffective in big data environments. Designing ultra-low complexity algorithms for any big data analysis and processing problem is a complex task.

Conclusion

Basic mathematics plays a role in Artificial Intelligence (AI) modeling, encompassing mathematical logic, philosophy, analysis methods, and thinking. It forms the foundation for innovative AI and data processing methods. As AI progresses towards simulating human intelligence, basic mathematics will serve as the starting point for the next wave of mathematical applications. The reciprocal relationship between AI and basic mathematics will become more apparent in the future. Theoretical innovation, driven by basic research, is the catalyst for technological advancements. It involves exploring and revealing the nature and patterns of things, providing inspiration and theoretical basis for driving technological changes. Breakthroughs in theoretical systems or frameworks require advancements in major mathematical concepts. This integration of basic mathematics and AI reflects the essence of technological progress.

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