Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 15, No. 1, 2025

A Study on The Application of Artificial Intelligence in Mathematical Modeling

Yeping Sun*, Xiaoyang Zhao

Henan Polytechnic Institute, Nanyang, 473000, China
*Corresponding author: 64455048@qq.com

Abstract: This paper discusses the application of artificial intelligence in the field of mathematical modeling. It analyzes the unique advantages of AI techniques, such as machine learning and deep learning, in improving the efficiency of mathematical modeling and solving complex problems. The specific application scenarios of AI in mathematical modeling in various fields, including natural science, engineering technology, social economy and so on, are introduced in detail. At the same time, we analyze the challenges of data quality and model interpretability in the application process, and look forward to the future trend of the integration of AI and mathematical modeling. The aim is to reveal the changes brought by AI to mathematical modeling, to provide reference for research and practice in related fields, and to promote new breakthroughs in mathematical modeling under multidisciplinary cross-fertilization.[1].

Keywords: Artificial Intelligence; Mathematical Modeling; Machine Learning; Applied Research that.

1. Introduction

Mathematical modeling, as an effective means of solving practical problems by mathematical methods, plays a key role in many disciplines and fields. From the simulation of physical phenomena in natural sciences, to the optimal design of systems in engineering and technology, to the prediction of market trends in socio-economic fields, mathematical modeling provides a clear logical framework and quantitative analysis for the solution of complex problems. However, with the increasing complexity of practical problems, traditional mathematical modeling methods face many challenges in dealing with large-scale data, highly nonlinear relationships and dynamic processes. The rapid development of artificial intelligence technology has injected new vitality into mathematical modeling.

2. The Technological Basis of Artificial Intelligence and Its Advantages in Mathematical Modeling

2.1. The technological basis of artificial intelligence

Machine learning, as one of the core fields of artificial intelligence, covers various paradigms such as supervised learning, unsupervised learning and semi-supervised learning. Supervised learning learns from labeled data and constructs predictive models for classification or regression prediction of new data, and common algorithms include decision trees, support vector machines, neural networks, etc. Unsupervised learning seeks to discover the intrinsic structure and patterns of data from unlabeled data, such as clustering. Unsupervised learning is dedicated to discovering the intrinsic structure and pattern of data from unlabeled data, such as clustering algorithms, principal component analysis, etc. Deep learning, as a branch of machine learning, is based on deep neural networks, which automatically learns complex feature representations from a large amount of data by constructing neural network models containing multiple hidden layers, and has achieved great success in the fields of image recognition and speech recognition.

2.2. Advantages in mathematical modeling

Artificial intelligence shows significant advantages in mathematical modeling. First of all, its powerful data processing ability can quickly process massive data, mine valuable information from the data, and provide rich data support for the construction of mathematical models. Compared with traditional manual data processing, it greatly improves the efficiency and accuracy of data processing. Secondly, the self-learning ability of artificial intelligence makes the model able to adjust and optimize its own parameters according to new data, adapt to the dynamic changes of the problem, and improve the generalization ability of the model. For example, in time series prediction modeling, machine learning models can continuously learn new data patterns over time to improve the accuracy of prediction. Moreover, for complex nonlinear problems, artificial intelligence models such as neural networks can effectively solve highly nonlinear problems that are difficult to be handled by traditional mathematical models by constructing complex nonlinear mapping relationships, providing a more powerful tool for mathematical modeling.

3. Application Scenarios of Artificial Intelligence in Mathematical Modeling

3.1. In the field of natural sciences

In physics, mathematical modeling using artificial intelligence can be used to simulate complex physical systems. For example, when modeling the many-body problem in quantum mechanics through deep learning models, traditional mathematical methods are difficult to solve accurately due to high computational complexity, while deep learning models can predict the quantum state and physical properties of the many-body system by learning from a large amount of simulation data. In astronomy, AI-assisted mathematical modeling is used for galaxy evolution simulation and celestial

image analysis. The processing of astronomical observation data by machine learning algorithms can quickly identify the characteristics of celestial objects and classify the types of galaxies, providing new methods and perspectives for astronomical research.

3.2. The field of engineering and technology

In mechanical engineering, artificial intelligence in mathematical modeling can be used for fault diagnosis and predictive maintenance of mechanical equipment. By collecting and analyzing the vibration, temperature and other multi-source data during the operation of the equipment, and using machine learning algorithms to build fault diagnosis models, it can predict the possible failures of the equipment in advance and avoid the losses caused by the sudden failure of the equipment. In communication engineering, the use of artificial intelligence to optimize the mathematical model of the communication network, such as deep learning algorithms for network traffic prediction, rational allocation of network resources, improve network communication efficiency and stability.[2]

3.3. The socio-economic sphere

In economics, artificial intelligence applied to mathematical modeling can be used for economic trend forecasting and policy assessment. For example, machine learning algorithms can be used to analyze macroeconomic data, build economic forecasting models, predict economic growth trends, inflation rates and other indicators, and provide a reference basis for the government to formulate economic policies. In the field of marketing, artificial intelligence is used to model and analyze consumer behavioral data, dig out consumer buying preferences, consumption patterns and other information, and help enterprises formulate accurate marketing strategies to improve market competitiveness.

4. Challenges Faced by Artificial Intelligence in Mathematical Modeling Applications

4.1. Data quality issues

High-quality data is the basis for AI to work well in mathematical modeling. However, in practical applications, data often have problems such as noise, missing values and outliers. Noisy data may interfere with the learning process of the model, resulting in inaccurate model predictions; the existence of missing values affects the integrity of the data, resulting in the loss of some information; outliers may have a greater impact on the model, especially in some algorithms that are sensitive to the distribution of data. Solving the data quality problem requires a lot of time and effort for data cleaning and preprocessing.

4.2. Model interpretive challenges

Many AI models, especially deep learning models, are highly complex and black-box in nature, and their internal decision-making process is difficult to understand intuitively. In mathematical modeling applications, especially in areas that require a high level of decision making, such as medical diagnosis, financial risk assessment, etc., the interpretability of the model is crucial. The lack of interpretability makes it difficult for users to trust the output results of the model, which limits the application of artificial intelligence in mathematical modeling in these fields.

4.3. High demand for computing resources

The training of AI models, especially deep learning models, usually requires a large amount of computational resources, including high-performance graphics processing units (GPUs), large-scale memory, and long computation time. This is a major obstacle for some research teams or enterprises with limited resources. The high computational cost includes not only the cost of purchasing hardware and equipment, but also the cost of energy consumption during operation, which limits the wide application of AI in mathematical modeling.

5. Prospects for the Application of Artificial Intelligence in Mathematical Modeling

5.1. Deepening multidisciplinary integration

In the future, the integration of artificial intelligence and mathematical modeling will further promote the cross-disciplinary development. In the field of biology, the combination of AI and mathematical modeling can be used to model and analyze the complex behavior of biological systems, such as protein structure prediction, biological neural network simulation, etc., to promote the development of biomedical research. In environmental science, the use of AI-assisted mathematical modeling can be used to study complex environmental problems such as climate change and ecosystem evolution, and provide decision-making support for environmental protection and sustainable development. Through interdisciplinary cooperation, the knowledge and technology of different fields are combined to expand the scope of application of artificial intelligence in mathematical modeling.

5.2. Model interpretability research breakthroughs

With the deepening of research, breakthroughs in the interpretability of AI models are expected. Researchers are exploring the development of new technologies and methods, such as interpretable machine learning algorithms and visualization tools, to make the decision-making process of AI models more transparent and understandable. For example, by analyzing the internal structure of neural network models, explanatory metrics can be developed to help users understand how the models process and make decisions on input data, thus improving the credibility and acceptability of the models in mathematical modeling applications in critical areas.

6. Conclusions

The application of artificial intelligence in mathematical modeling provides innovative methods and tools for solving complex practical problems and shows great potential and advantages in many fields. Although the current application process faces challenges such as data quality, model interpretability and computational resources, these problems are expected to be gradually solved with the continuous development of technology and in-depth research[3]. In the future, the deep integration of artificial intelligence and mathematical modeling will promote the cross-disciplinary development, play an important role in more fields, provide

more powerful tools and methods for human beings to understand the world and solve complex problems, and promote the progress and development of society.

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