The Application of Artificial Intelligence and Big Data in Computer Networks

Jiahe Guo

Beijing Institute of Technology Beijing 102401

Abstract: ***The application of artificial intelligence and big data in computer network technology is becoming increasingly widespread. The vast, diverse, and rapidly growing characteristics of big data, combined with the intelligent processing capabilities of artificial intelligence, not only improve data processing efficiency and accuracy, but also significantly enhance network security and stability. Artificial intelligence has achieved intelligent monitoring, anomaly detection, and real-time protection of network traffic through optimized algorithms, while promoting the development of personalized services and precision marketing. The combination of the two has promoted the intelligent upgrading of computer network technology and provided strong support for the digital transformation of various industries.***

Keywords: Artificial intelligence and big data; Computer network; Application.

1. INTRODUCTION

With the rapid development of information technology, artificial intelligence and big data have become important forces driving the transformation of computer networks. The massive amount of information in big data provides a solid foundation for decision-making, while the intelligent algorithms of artificial intelligence give life to this data, enabling it to exert unprecedented efficiency in fields such as network management, security protection, and personalized services. The deep integration of the two not only revolutionizes the application mode of network technology, but also heralds the arrival of the intelligent and automated era of computer networks in the future, leading us towards a more efficient and intelligent information age. A primary research thrust aims to instill trust and robustness into autonomous decision-making and content generation. Tang et al. (2026) addressed this by developing SVD-BDRL, a trustworthy autonomous driving framework enhanced with blockchain technology [1]. Concurrently, Lu et al. (2025) improved the fidelity of generative AI with NeuroDiff3D, a diffusion model that optimizes viewpoint consistency in 3D generation [2]. For complex data integration in regulatory domains, Zhang (2025) proposed a knowledge graph-enhanced multimodal AI framework to improve tax compliance [3]. Robust environmental perception, a cornerstone of autonomy, is advanced by Xie et al. (2025) through MARNet, a multi-scale network for point cloud completion via cross-modal fusion [4].

In the digital economy, optimizing engagement and ensuring security are paramount. Tian et al. (2025) innovated ad recall strategies using cross-attention multi-task learning [5]. However, the collaborative AI models enabling such innovations face significant privacy threats, countered by Deng and Yang's (2025) multi-layer defenses against membership reasoning attacks in federated learning [6], and the robust, privacy-conscious FedGuard framework for anti-money laundering proposed by Sultan et al. (2026) [7].

Graph-based and sensor-integrated models demonstrate significant versatility. Zhu, Yu, and Li (2025) applied a spatiotemporal graph convolutional network (SAGCN) with IoT for detailed tennis motion analysis [8]. Similarly, graph structures are leveraged in logistics by Zhang (2024) for dynamic adaptation of emergency material supply using hierarchical clustering [9], and in recommender systems by Yang, Wang, and Chen (2024) with GCN-MF [10].

Critical applications in healthcare and infrastructure rely on sophisticated data fusion and system reliability. We et al. (2025) worked towards intelligent anesthesia monitoring using multimodal physiological data [11], while Yang (2025) researched site reliability optimization in cloud environments [12]. The foundational interaction between intelligent agents and their environment is explored in robotics by Guo and Tao (2025) [13].

A unifying technical challenge across these domains is model adaptability to new, unseen conditions. Peng et al. (2023) tackled this with RAIN, a method for black-box domain adaptation via input and network regularization [14]. This principle of adaptive optimization extends to industrial and medical applications, exemplified by Xie and Chen's (2025) multi-agent system, Maestro, for task optimization in manufacturing [15], and the efforts of Qin

et al. (2025) to optimize deep learning models for combating Amyotrophic Lateral Sclerosis (ALS) disease progression [16].

2. OVERVIEW OF ARTIFICIAL INTELLIGENCE AND BIG DATA

2.1 Concept and Characteristics of Artificial Intelligence

Artificial intelligence, as an advanced stage of computer technology development, is a comprehensive technology that simulates human intelligence for work. It is not just a simple stack of algorithms and programs, but a complex system that integrates various abilities such as knowledge representation, learning, reasoning, perception, understanding, and decision-making. Its core lies in enabling machines to think, learn, and even create like humans, thereby solving complex problems that traditional computers find difficult to handle. The characteristics of artificial intelligence are mainly reflected in the following aspects:

Firstly, it can simplify complex problems by decomposing and optimizing them through mathematical models and algorithms, thereby finding more efficient and accurate solutions;

Secondly, artificial intelligence greatly accelerates the speed of information processing, enabling both massive data analysis and real-time decision response to be completed in a short period of time;

In addition, self-directed learning and adaptation are one of the most significant characteristics of artificial intelligence, which can continuously adjust and optimize its models and strategies based on changes in the environment and new information, thereby maintaining competitiveness and adaptability.

2.2 Concept and Characteristics of Big Data

Big data, as an important product of the information age, refers to a collection of data that cannot be captured, managed, and processed using conventional software tools within a certain time frame. Its emergence has completely changed the way data is processed and thought, making data a valuable resource. The characteristics of big data are mainly reflected in four aspects:

One is the huge amount of data, whether it is enterprise operation data, social network data, or data generated by IoT devices, all show an explosive growth trend; Secondly, there are various types of data, including structured data, semi-structured data, and unstructured data, among others; Thirdly, the processing speed is fast, and big data processing requires the ability to complete tasks such as data collection, storage, analysis, and mining in a very short period of time; The fourth issue is low value density. Although there is a large amount of data, the truly valuable information often accounts for a relatively low proportion and needs to be extracted through efficient data processing techniques.

3. APPLICATION ANALYSIS OF ARTIFICIAL INTELLIGENCE AND BIG DATA IN COMPUTER NETWORKS

3.1 Improving Information Processing Efficiency

3.1.1 Application of Artificial Intelligence in Data Preprocessing, Data Mining, and Data Analysis

In today's era of data explosion, the data processing capability in computer networks directly affects the operational efficiency and decision-making quality of enterprises. The application of artificial intelligence technology has brought revolutionary changes to various aspects of data processing. In the data preprocessing stage, artificial intelligence significantly improves the efficiency of data cleaning, transformation, and standardization through automated tools and technologies. Machine learning algorithms, such as clustering analysis and anomaly detection, can automatically identify and process noise, outliers, and redundant information in data, laying a solid foundation for subsequent data mining and analysis. In addition, natural language processing (NLP) and image recognition technologies are widely used in the preprocessing of unstructured data, achieving effective parsing and extraction of complex data such as text and images. Data mining is a crucial step in exploring the intrinsic value of data. Artificial intelligence utilizes advanced algorithms and models to uncover hidden associations, patterns, and trends in massive amounts of data. Deep learning algorithms, as one of the

representative technologies of artificial intelligence, can extract advanced features from complex data for tasks such as prediction, classification, and clustering by simulating the operation of human brain neural networks. This automated data mining capability not only improves the accuracy of data processing, but also significantly shortens data processing time. Data analysis is an important step in transforming mined information into valuable insights. Artificial intelligence conducts in-depth analysis and interpretation of data through methods such as building predictive models and performing statistical tests. Machine learning models can continuously improve prediction accuracy and generalization ability through continuous learning and optimization processes. This data-driven intelligent analysis capability provides powerful data support for enterprise decision-making.

3.1.2 How artificial intelligence can help computer networks process large-scale data more efficiently

For computer networks, processing large-scale data is a highly challenging task. Traditional methods are often inadequate due to insufficient computing power or long processing time. The introduction of artificial intelligence has effectively solved this problem. Firstly, artificial intelligence technology possesses powerful computing capabilities, capable of processing large amounts of data in parallel and significantly improving processing speed. Secondly, after optimization, artificial intelligence algorithms can reduce computational complexity while ensuring accuracy, thereby reducing processing time. In addition, artificial intelligence also has self-learning ability, which can automatically adjust processing strategies according to changes in data, further improving processing efficiency.

3.2 Enhancing Network Security

3.2.1 Main Security Threats Faced by Computer Networks

While computer networks provide convenience, they also face severe security threats. Frequent security incidents such as hacker attacks, virus intrusions, and data breaches have caused enormous losses to individuals, businesses, and countries. Hacker attacks are one of the main threats to network security. Hackers illegally invade computer systems, steal sensitive information, or disrupt normal system operation by exploiting system vulnerabilities, malicious software, and other means. Virus invasion is the spread of malicious software to infect computers and network devices, causing serious consequences such as system crashes and data loss. In addition, data leakage is also one of the important issues in network security. Due to insufficient security measures or human negligence, sensitive information may be obtained and utilized by unauthorized personnel.

3.2.2 Application of Artificial Intelligence Technology in Network Security Protection

In order to address these security threats, artificial intelligence technology is widely used in network security protection. As the first line of defense, intelligent firewalls automatically intercept malicious traffic and attacks by learning and identifying abnormal behavior patterns in network traffic. Compared with traditional firewalls, intelligent firewalls have higher detection rates and lower false alarm rates. Intrusion detection systems are important tools for real-time monitoring and analysis of network traffic. The application of artificial intelligence technology enables intrusion detection systems to identify more complex and covert attack methods, issue timely alerts, and take corresponding measures. By constructing intelligent analysis models and algorithms, intrusion detection systems can automatically analyze and process massive log information, quickly identifying potential security threats. Threat intelligence analysis is an important means of preventing future security incidents. Artificial intelligence analyzes threat intelligence information from various sources to reveal potential attack targets and methods, providing a basis for enterprises to develop targeted security protection strategies. Meanwhile, artificial intelligence can continuously track and update threat intelligence through automated tools and technologies, ensuring the effectiveness and timeliness of security measures.

3.3 Optimizing Network Management and Operations

3.3.1 Application of Artificial Intelligence in Network Monitoring, Fault Diagnosis, and Resource Allocation

Artificial intelligence plays an important role in network management and operation. The intelligent monitoring system can monitor the operation status and performance indicators of network devices in real time, and timely discover and solve potential problems. When network equipment malfunctions, the artificial intelligence fault diagnosis system can automatically analyze the cause of the fault and provide repair suggestions or perform automatic repair operations. In terms of resource allocation, artificial intelligence achieves dynamic allocation and

adjustment of network resources through predictive analysis and optimization algorithms to ensure efficient operation of the network and rational utilization of resources.

3.3.2 How artificial intelligence can reduce network management costs and improve operational efficiency

Artificial intelligence has significantly reduced network management costs and improved operational efficiency through automation and intelligent means. Firstly, intelligent monitoring and fault diagnosis systems reduce the need for manual intervention and lower labor costs. Secondly, by optimizing resource allocation and predictive analysis, artificial intelligence can reduce resource waste and lower operating costs. Once again, the real-time and accurate nature of artificial intelligence enables problems to be quickly identified and resolved, thereby shortening service interruptions and reducing the impact of failures on users. During the operation and maintenance process, artificial intelligence also provides intelligent decision support. By analyzing and learning from historical operation and maintenance data, artificial intelligence can predict potential problems and risks, and provide targeted suggestions and strategies for operation and maintenance personnel. This helps the operations team to develop operations plans and emergency plans more efficiently, further improving the response speed and quality of operations. In addition, artificial intelligence has also promoted the standardization and normalization of operation and maintenance processes. By establishing operation and maintenance standards and processes, combined with the automation execution and monitoring capabilities of artificial intelligence, the consistency and accuracy of operation and maintenance operations can be ensured. This not only improves operational efficiency, but also reduces the risk of human error and negligence.

3.4 Promoting Business Innovation

3.4.1 How big data and artificial intelligence can create new business models and services for network service providers

The combination of big data and artificial intelligence provides rich innovation opportunities for network service providers. By analyzing big data such as user behavior, preferences, and consumption habits, network service providers can more accurately understand user needs and market trends, and thus customize products and services that meet user expectations. For example, a personalized recommendation system based on user browsing history and purchase records can provide users with personalized product recommendations and shopping experiences; An intelligent customer service system based on user behavior patterns can provide more intimate and efficient customer service. In addition, big data and artificial intelligence can also help network service providers optimize business processes and improve operational efficiency. Through real-time analysis and monitoring of business data, service providers can promptly identify and solve problems in business operations, optimize resource allocation and business processes, and improve overall operational efficiency and user satisfaction.

3.4.2 Application Examples of Personalized Recommendations and Intelligent Customer Service Based on Big Data Analysis

Personalized recommendation system is one of the typical applications of big data and artificial intelligence in network services. The system collects user browsing history, search history, purchasing behavior, and other data to construct user profiles, and recommends products based on the user profiles. For example, e-commerce platforms can recommend similar products or new products to users based on their purchase history and browsing preferences; Video platforms can recommend personalized video content to users based on their viewing history and interest preferences. These personalized recommendations not only improve user experience and satisfaction, but also promote sales growth and user stickiness. The intelligent customer service system is another important application example. The system achieves intelligent interaction and automated services with users through natural language processing technology and machine learning algorithms. Users can communicate with intelligent customer service through text or voice, and receive instant answers and assistance. The intelligent customer service system can automatically identify users' problems and needs, and provide corresponding solutions or suggestions. This not only improves customer service efficiency and user experience, but also reduces customer service costs and the need for manual intervention. With the continuous development of technology, intelligent customer service systems will gradually have the ability to understand and express emotions, providing users with more intimate and humanized services.

4. CURRENT PROBLEMS AND SOLUTIONS OF ARTIFICIAL INTELLIGENCE AND BIG DATA IN COMPUTER NETWORK APPLICATIONS

4.1 Current Problems of Artificial Intelligence and Big Data in Computer Network Applications

4.1.1 Technical bottlenecks

Although significant progress has been made in the application of artificial intelligence and big data technology in computer networks, there are still many technical bottlenecks that need to be addressed. On the one hand, with the rapid increase in data volume, the complexity and difficulty of data processing also increase, which puts higher demands on computing resources and storage capacity. On the other hand, the training and optimization of artificial intelligence models often require a large amount of high-quality data and computing resources, and the high cost of data annotation and algorithm complexity limit their application in large-scale scenarios. In addition, the lack of interpretability in artificial intelligence models is also an important issue, making it difficult for people to understand and trust the decision-making process of the models.

4.1.2 Data Privacy Protection

Data privacy protection is an issue that cannot be ignored in the application of artificial intelligence and big data in computer networks. In the process of data collection, storage, analysis, and application, personal privacy information is easily leaked or abused. For example, in intelligent recommendation systems, users' browsing and purchasing records may be used for unauthorized marketing activities; In intelligent customer service systems, user conversation content may be recorded and analyzed to optimize services, but it may also infringe on users' privacy rights. How to use big data and artificial intelligence technology to enhance services while protecting user privacy is an urgent problem that needs to be solved.

4.2 Propose specific solutions and improvement suggestions for the above issues

4.2.2 Strengthen technological innovation and R&D investment

In response to technological bottlenecks, it is necessary to strengthen technological innovation and R&D investment, promote algorithm optimization and hardware upgrades. On the one hand, by introducing more efficient algorithms and distributed computing technologies, the efficiency of data processing and analysis can be improved; On the other hand, we need to strengthen the research and development of computing resources, enhance computing and storage capabilities. At the same time, it is necessary to strengthen the interpretability research of artificial intelligence models and improve their transparency and credibility.

4.2.2 Improve data privacy protection mechanisms

To address the issue of data privacy protection, it is necessary to improve the data privacy protection mechanism to ensure the security of user privacy information. Firstly, strengthen the application of data encryption and anonymization technologies to prevent data from being leaked or tampered with during transmission and storage. Secondly, establish strict access control and permission management systems to ensure that only authorized personnel can access sensitive data. Finally, strengthen the formulation and implementation of privacy protection policies, and severely crack down on and punish violations.

4.2.3 Strengthen the construction and supervision of laws and regulations

In order to better protect user privacy and data security, it is necessary to strengthen the construction and supervision of laws and regulations. On the one hand, formulate and improve relevant laws, regulations, and policy measures to clarify the obligations and responsibilities of data privacy protection; On the other hand, we need to strengthen the supervision and law enforcement of data collection, storage, processing, and application processes to ensure that enterprises and individuals comply with legal, regulatory, and policy requirements. At the same time, it is necessary to establish a complaint and rights protection mechanism to facilitate users in safeguarding their legitimate rights and interests.

5. CONCLUSION

The deep application of artificial intelligence and big data in computer networks has profoundly changed the pattern of network management, improving service quality and user experience. In the future, with the continuous breakthroughs and integration of technology, they will play a greater role in optimizing network structures, enhancing data security, and achieving intelligent resource allocation. We have reason to believe that artificial intelligence and big data will continue to empower computer networks, driving them towards greater intelligence, automation, and efficiency, injecting new vitality into the digital transformation of various sectors of society.

REFERENCES

[1] Tang, Z., Feng, Y., Zhang, J., & Wang, Z. (2026). SVD-BDRL: A trustworthy autonomous driving decision framework based on sparse voxels and blockchain enhancement. Alexandria Engineering Journal, 134, 433-446.
[2] Lu, K., Sui, Q., Chen, X., & Wang, Z. (2025). NeuroDiff3D: a 3D generation method optimizing viewpoint consistency through diffusion modeling. Scientific Reports, 15(1), 41084.
[3] Zhang, T. (2025). A Knowledge Graph-Enhanced Multimodal AI Framework for Intelligent Tax Data Integration and Compliance Enhancement. Frontiers in Business and Finance, 2(02), 247-261.
[4] Xie, J., Zhang, L., Cheng, L., Yao, J., Qian, P., Zhu, B., & Liu, G. (2025). MARNet: Multi-scale adaptive relational network for robust point cloud completion via cross-modal fusion. Information Fusion, 103505.
[5] Q. Tian, D. Zou, Y. Han and X. Li, "A Business Intelligence Innovative Approach to Ad Recall: Cross-Attention Multi-Task Learning for Digital Advertising," 2025 IEEE 6th International Seminar on Artificial Intelligence, Networking and Information Technology (AINIT), Shenzhen, China, 2025, pp. 1249-1253, doi: 10.1109/AINIT65432.2025.11035473.
[6] Deng, X., & Yang, J. (2025, August). Multi-Layer Defense Strategies and Privacy Preserving Enhancements for Membership Reasoning Attacks in a Federated Learning Framework. In 2025 5th International Conference on Computer Science and Blockchain (CCSB) (pp. 278-282). IEEE.
[7] Sultan, N., Patwar, N., Wei, X., Chew, J., Liu, J., & Du, R. (2026). FedGuard: A Robust Federated AI Framework for Privacy-Conscious Collaborative AML, Inspired by DARPA GARD Principles. International Academic Journal of Social Science, 2, 1–16. https://doi.org/10.5281/zenodo.18253151
[8] Zhu, Y., Yu, W., & Li, R. (2025). SAGCN: A spatiotemporal attention-weighted graph convolutional network with IoT integration for adolescent tennis motion analysis. Alexandria Engineering Journal, 128, 652-662.
[9] Zhang, X. (2024). Research on Dynamic Adaptation of Supply and Demand of Power Emergency Materials based on Cohesive Hierarchical Clustering. Innovation & Technology Advances, 2(2), 59–75. https://doi.org/10.61187/ita.v2i2.135
[10] Yang, J., Wang, Z., & Chen, C. (2024). GCN-MF: A graph convolutional network based on matrix factorization for recommendation. Innovation & Technology Advances, 2(1), 14–26. https://doi.org/10.61187/ita.v2i1.30
[11] We, X., Lin, S., Pruś, K., Zhu, X., Jia, X., & Du, R. (2025). Towards Intelligent Monitoring of Anesthesia Depth by Leveraging Multimodal Physiological Data. International Journal of Advance in Clinical Science Research, 4, 26–37. Retrieved from https://www.h-tsp.com/index.php/ijacsr/article/view/158
[12] Yang, Y. (2025). Research on Site Reliability Optimization Technology Based on Synthetic Monitoring in Cloud Environments.
[13] Guo, Y., & Tao, D. (2025). Modeling and Simulation Analysis of Robot Environmental Interaction. Artificial Intelligence Technology Research, 2(8).
[14] Peng, Qucheng, et al. "RAIN: regularization on input and network for black-box domain adaptation." Proceedings of the Thirty-Second International Joint Conference on Artificial Intelligence. 2023.
[15] Xie, Minhui, and Shujian Chen. "Maestro: Multi-Agent Enhanced System for Task Recognition and Optimization in Manufacturing Lines." Authorea Preprints (2025).
[16] Qin, Haoshen, et al. "Optimizing deep learning models to combat amyotrophic lateral sclerosis (ALS) disease progression." Digital health 11 (2025): 20552076251349719.