

A Concise Review of AI-Driven Cross-Domain Technological Innovation and Application Frontiers

Abstract

The rapid advancement of artificial intelligence (AI) technology has spurred innovative breakthroughs in healthcare, quantum physics, digital commerce, cybersecurity, and financial governance. Based on the latest research findings from 2022 to 2026, this paper summarizes the core technological progress and application value across six key domains, analyzes cross-domain collaborative potential and common challenges, and provides a concise reference for relevant research and practical endeavors.

1 Introduction

In the era of the digital economy, AI technology has broken down domain boundaries and plays a pivotal role in scenarios such as medical image precision enhancement, quantum system modeling, digital commerce privacy protection, microservice security defense, and financial governance (including investment optimization and ESG). This paper integrates the latest research literature, focuses on the core methods and application effectiveness of AI innovation in various fields, and reveals the trend of cross-domain technological integration.

2 Core Technological Innovations and Applications

2.1 Healthcare Domain

2.1.1 Lung Nodule Segmentation

Accurate lung nodule segmentation is critical for early lung cancer diagnosis, but traditional algorithms suffer from insufficient precision in handling heterogeneous nodules. The PDU-Net algorithm proposed by Chang et al. [1] integrates a path aggregation structure with a dual attention mechanism, optimizing feature transmission efficiency and enhancing the extraction of key regions. This significantly improves the segmentation accuracy of nodules of varying sizes, laying a technical foundation for computer-aided diagnosis systems.

2.1.2 HIV Treatment Adherence Measurement

Electronic Health Record (EHR) phenotyping is an important method for assessing treatment adherence among people living with HIV (PLHIV). Yue et al. [9] proposed an innovative EHR phenotyping approach targeting PLHIV in the "All of Us" cohort, focusing on disparities and inequalities in the HIV care continuum. This data-driven solution enables precise intervention for treatment adherence, advancing the personalization and equity of HIV care.

2.2 Quantum Geometry Modeling

Traditional methods face bottlenecks in modeling the quantum geometry of fractional Chern insulators. Wu et al. [2] pioneered the application of unsupervised learning in this field, constructing a data-driven modeling framework that breaks free from reliance on theoretical assumptions. This achieves accurate characterization of quantum states, providing a new pathway for quantum material design and the industrialization of quantum technology.

2.3 Digital Commerce Innovation

To address the conflict between privacy protection and collaborative synergy in digital commerce, Yi [3][7][8] proposed three core frameworks: a federated and differentially private incentive-marketing framework enabling privacy-preserving cross-channel measurement; a trusted AI commercialization infrastructure with a multi-tenant architecture lowering the application threshold for small and medium-sized enterprises (SMEs); and a privacy-enhanced ad targeting framework for social e-commerce integrating federated learning and zero-knowledge proof. These frameworks balance user privacy with creator monetization, driving the compliant development of the industry.

2.4 Microservice Security Defense

The widespread adoption of microservice architectures has intensified security risks. Zhou [4][5] proposed two innovative solutions: the M-VP2 method, which optimizes vulnerability patch planning based on multi-agent reinforcement learning to balance cost and repair efficiency; and an AI-driven hybrid SAST-DAST-SCA-IAST framework that integrates multi-dimensional security detection technologies. This framework enables risk-based vulnerability prioritization, improving the full-lifecycle security defense system for microservices.

2.5 Financial Governance Domain

2.5.1 Factors Influencing Corporate ESG Ratings

Based on empirical analysis of Chinese stock market data, Liu [6] found a significant negative correlation between corporate financial constraints and ESG ratings. SMEs often exhibit weaker ESG performance due to limited resources. This finding provides important references for investor decision-making and regulatory policy formulation, revealing the "Matthew effect" in ESG ratings.

2.5.2 Portfolio Optimization

Portfolio optimization relies on accurate market forecasting. Li and Liu [10] proposed a portfolio optimization method based on the LSTM forecasting model, leveraging the long short-term memory network's strength in processing time-series data to improve market trend prediction accuracy. This AI-driven technical solution helps investors construct efficient and robust investment portfolios.

3 Common Challenges and Collaborative Potential

3.1 Common Challenges

All domains face three core challenges: balancing data privacy with modeling quality, high costs of technology implementation, and a shortage of interdisciplinary talents. These factors restrict the large-scale application of AI technology.

3.2 Collaborative Potential

Privacy-preserving computing technologies (e.g., federated learning, differential privacy) can be reused across healthcare and digital commerce; AI prediction and risk assessment methods are applicable to portfolio optimization, microservice security, and ESG ratings; and modeling approaches such as unsupervised learning and deep learning can provide insights for complex problems in quantum systems and medical phenotyping. Cross-domain technology sharing and interdisciplinary talent cultivation are key to future development.

4 Conclusion

AI-driven customized innovations across six domains have become a critical driver for solving core problems, with cross-domain integration emerging as a future trend. Future research should focus on three directions: deep integration of privacy-preserving computing with AI modeling, lightweight implementation of technologies, and construction of interdisciplinary systems. This will enable AI to provide stronger support for the high-quality development of the digital economy.

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