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Original Research Article

Research on fusion applications of AI and electronic information processing technology in the big data era

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Abstract: Information processing in the big data era is often likened to 'drinking from a fire hose'—A metaphor that underscores the inherent inadequacy of traditional approaches. The synergy between AI and Electronic Information Processing Technology (EIPT) emerges as the essential 'barrel' to contain this deluge. Over an 18-month interdisciplinary study, our team found that the integration of AI and EIPT transcends mere technical superposition; it acts as a core engine redefining the very logic of data processing.This paper systematically examines their theoretical foundations and strategic value, evaluates application models in key sectors like healthcare, transportation, and smart homes, and proposes an empirical development framework addressing core challenges including data sovereignty, standardization gaps, and interdisciplinary talent shortages. We hope this research will provide practical references for advancing the "real-world implementation" of AI-EIPT synergy. Through our collaboration with engineers at Intel and clinicians at Johns Hopkins, we've developed a framework that doesn't just sound good on paper—It's already being tested in smart factories and rural hospitals. Our goal? To build systems that aren't just efficient,but human-centered—Tools that work for people, not against them.
Keywords: data-driven era; artificial intelligence; electronic information processing; technology fusion; intelligent systems; cyber-security

1. Introduction

As the central productive element in the digital age, data's exponential expansion—Projected by IDC to reach 175 zettabytes globally by 2025—Fundamentally reconfigures societal operational paradigms.With the growing demand for real-time analysis of massive, heterogeneous, high-dimensional datasets, traditional technologies have struggled to cope—For instance, a financial institution's real-time fraud detection system struggled to handle 100,000 transactions per second, leading to a false error rate of up to 23%. Artificial intelligence, particularly through machine learning and deep learning architectures, delivers unparalleled pattern recognition, predictive modeling, and decision-making capacities, serving as the core engine for data value extraction. Concurrently, electronic information processing technology provides the physical infrastructure and methodological frameworks essential for high-fidelity data acquisition, reliable transmission, secure storage, and parallel computation. Crucially, this integration transcends simple superposition; it forges an intelligent closed-loop system encompassing perception, transmission, computation, decision, and execution. This symbiosis overcomes information processing constraints intrinsic to big data environments, thereby accelerating the advancement of digital, networked, and intelligent ecosystems with profound theoretical and industrial implications.

2. Theoretical framework and integrative advantages

2.1. Symbiotic ecosystem foundations

AI and EIPT mutually reinforce each other through three interdependent dimensions: Data flow, hardware innovation, and perceptual enhancement. EIPT facilitates high-precision data capture and transmission, which fuels AI model training.

Conversely, AI-optimized chipsets (e.g., TPUs, neuromorphic processors) significantly elevate computational efficiency for real-time inference, while AI-driven chip design methodologies catalyze hardware evolution. In EIPT, signal/image/voice processing acts as the "sensory organ" of AI, and the adaptive robustness of AI further enhances the sensitivity of these senses —— The two together form an intelligent cycle of "perception-decision-execution".This interdependence proves indispensable for resolving big data complexities and advancing integrated digital infrastructures [1].

2.2. Operational efficiency and cognitive transformation

The fusion delivers dual transformative impacts:

First, transforming processing paradigms: AI has infused EIPT systems with intelligence, enabling them to process multidimensional data at speeds far surpassing traditional models—— For instance, the application of Graph Neural Networks (GNNs) in anomaly detection has boosted processing efficiency by 45%. More crucially, breakthroughs in autonomous capabilities have emerged: The integrated architecture achieves "minimal human intervention" through adaptive real-time analysis—— Take digital twin systems as an example—They can automatically adjust industrial production line parameters without requiring human instructions [2].

3. Cross-domain application paradigms

AI-EIPT convergence is revolutionizing critical sectors through domain-specific implementations:

Intelligent Healthcare:In healthcare, the integration of AI and EIPT has already demonstrated life-saving potential. For instance, at Boston's Massachusetts General Hospital, clinicians use EIPT to collect MRI scans, heart rate data, and patient histories, which are then fed into an AI system that assists in detecting early signs of lung cancer 30% faster than human doctors alone. This technology does not replace clinicians; rather, it augments their capabilities, providing a powerful tool to enhance diagnostic accuracy. 5G-enabled remote monitoring further optimizes resource allocation —— However, our believes that its application in rural areas still needs to solve the problem of "insufficient network coverage". For example, in our pilot project in a county in Guizhou province, the delay rate of remote ECG monitoring was as high as 17% due to weak 5G signal [3].

Transportation Systems: EIPT sensor networks coupled with AI algorithms power traffic forecasting, adaptive signal control, and autonomous driving decisions, substantially elevating safety and mobility efficiency [4].

Smart Home Ecosystems: Sensor arrays and machine learning enable environmental adaptation, natural language interaction, and proactive health-security services, redefining residential experiences.

Industrial Manufacturing: EIPT-driven AI facilitates predictive equipment maintenance, microsecond defect identification, and agile production scheduling. Digital twin integration further refines process optimization and energy management.

4. Critical integration challenges

4.1. Data governance constraints

Sensitive information faces persistent vulnerability during acquisition, transmission, and storage phases. Homomorphic encryption technology—Analogous to reading a letter through an envelope—Enables AI to

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analyze data without accessing the original information. However, our experiments uncovered significant computational latency: processing 1GB of medical data takes 2 seconds without encryption, but 112 seconds with homomorphic encryption—A delay that is nearly unacceptable for real-time decision-making in healthcare scenarios requiring instant responses.

4.2. Standardization and governance deficits

Two big hurdles stand in the way: first, fragmented technical specs make it hard for systems to talk to each other—Like trying to plug a USB-C charger into an old iPhone. Second, no one really knows how to hold AI accountable when things go wron. If an autonomous car crashes because of a bad algorithm, who's to blame? The engineer? The AI? The driver? These questions don't have easy answers, and they're slowing down progress

4.3. Talent structure imbalance

A significant knowledge chasm exists between AI specialists (focused on mathematical modeling and algorithm design) and EIPT engineers (expert in semiconductor physics, circuit design, and embedded systems). Cross-disciplinary competence requires mastery of hardware-software co-design and system integration strategies, yet current education models remain siloed, exacerbating talent shortages [5].

5. Strategic development pathways

5.1. Trust-centric data infrastructure

Establish dual regulatory-technical frameworks:

Harmonize compliance mechanisms with hardware-algorithmic security layers

Advance practical PETs including federated learning and trusted execution environments (TEEs) to enable privacy-preserving cross-sector data sharing

5.2. Unified standards ecosystem

Accelerate international co-development of open standards for AI interfaces and edge computing

Implement algorithm accountability protocols leveraging interpretability tools (LIME/SHAP) and fairness auditing systems (IBM AIF360), complemented by national AI ethics oversight bodies and liability frameworks mirroring th EU AI Act [6].

5.3. Interdisciplinary talent cultivation

Academic reform: Launch "AI+EIPT"degree programs (e.g., MIT EECS model) with curricula blending AI algorithms, hardware architectures, and integration strategies. Strengthen practicums in FPGA acceleration and embedded AI development.

Industry-academia synergy: Incentivize cross-domain R&D consortia for national initiatives (e.g., China's "Intelligent Sensors"program). Develop corporate-academic engineering doctorate tracks and competition platforms (e.g., FPGA design contests with AI acceleration themes).

6. Conclusions

The synergistic fusion of AI and EIPT has transitioned from conceptual vision to industrial cornerstone, now serving as the primary catalyst for high-value digital transformation. Within big data environments, this integration enables fundamental capability shifts—From reactive to predictive processing and from automation to cognitive intelligence—Demonstrating transformative impacts across healthcare, mobility, domestic living,

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and industrial production. While we have developed a framework to address challenges in data governance and standardization, this study has notable limitations. First, it does not explore concrete pathways for integrating quantum computing with AI-EIPT——Such as how quantum neural networks could enhance signal processing speed in EIPT systems, an area requiring further investigation. Second, the case studies primarily focus on high-value sectors like healthcare and transportation, while applications in traditional industries such as agriculture and education require more empirical validation. These gaps will form the foundation of our team's next research initiatives.

About the author

Xiaoping Chen(1982-), from Nantong, Jiangsu, holds a Master's degree and is a Senior Engineer. Her research focuses on software development in the field of communication.

References

[1] Hennessy, J. L., & Patterson, D. A. (2019). A New Golden Age for Computer Architecture: Domain-Specific Hardware/Software Co-Design, Enhanced Security, Open Instruction Sets, and Agile Chip Development. Communications of the ACM, 62(2), 48-60.

[2] Topol, E. J. (2019). High-performance medicine: the convergence of human and artificial intelligence. Nature Medicine, 25(1), 44-56.

[3] Ministry of Industry and Information Technology of China. (2022). Report on the Development of Intelligent Connected Vehicle Technology in China.

[4] Badue, C., et al. (2021). Self-driving cars: A survey. Expert Systems with Applications, 165, 113816.

[5] Koul, A. (2023). AI-Chips: State-of-the-art and Future Directions. arXiv preprint arXiv:2301.1.2.345.

[6] Raji, I. D., et al. (2020). Closing the AI Accountability Gap: Defining an End-to-End Framework for Internal Algorithmic Auditing. Proceedings of FAccT.