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Merging Blockchain Technology into Real-Time Learning AI System

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ABSTRACT
Blockchain constructs a distributed point-to-point system, which is a secure and verifiable mechanism for decentralized transaction validation and is widely used in financial economy, Internet of Things, large data, cloud computing, and edge computing. On the other hand, artificial intelligence technology is gradually promoting the intelligent development of various industries. As two promising technologies today, there is a natural advantage in the convergence between blockchain and artificial intelligence technologies. Blockchain makes artificial intelligence more autonomous and credible, and artificial intelligence can prompt blockchain toward intelligence. In this paper, we analyze the combination of blockchain and artificial intelligence from a more comprehensive and three-dimensional point of view. We first introduce the background of artificial intelligence and the concept, characteristics, and key technologies of blockchain and subsequently analyze the feasibility of combining blockchain with artificial intelligence. Next, we summarize the research work on the convergence of blockchain and artificial intelligence in home and overseas within this category. After that, we list some related application scenarios about the convergence of both technologies and also point out existing problems and challenges. Finally, we discuss the future work.
Keywords — Blockchain, Artificial Intelligence, Autonomy, Cryptography, Privacy Protection

I. INTRODUCTION

As the cutting-edge technologies nowadays, blockchain and artificial intelligence have attracted increasing attention due to the irreplaceable role that they play in technological innovation and industrial transformation [1–3]. The concept of artificial intelligence technology originated from the Dartmouth Society in 1956. As an essential branch of computer science, artificial intelligence technology is dedicated to the research and development of technical sciences used to simulate, extend, and expand human intelligence. In recent years, thanks to the tremendous breakthroughs made in machine learning (especially deep learning) [4] and the exponential growth of data, artificial intelligence has ushered in an explosive period. Due to its advantages in analysis, prediction, judgment, and decision-making, artificial intelligence can fundamentally empower industries such as security, finance, retail, transportation, and education [5–8]. Blockchain technology started relatively late, firstly starting with Bitcoin proposed by Satoshi Nakamoto in 2008. The blockchain is essentially a distributed ledger [9, 10]. It can use a decentralized consensus mechanism in an environment where different entities participate, without the intervention of a third trusted party. Blockchain also realizes the generation and verification of transactions in an untrusted distributed system, building trust at a lower cost [11]. It is precisely because of this that more and more researchers have concentrated on blockchain technology [12, 13].

Artificial intelligence and blockchain have their own advantages, but each one of them also has corresponding drawbacks. Blockchain has problems regarding energy consumption, scalability, security, privacy, and efficiency, while artificial intelligence faces issues such as interpretability and effectiveness. As two different research directions, they can be related to each other and have the advantages of natural integration. These two technologies have common demands for data analysis, security, and trust, and they can empower each other. For instance, artificial intelligence depends on three key elements: algorithms, computing power, and data, and the blockchain can break the island of data and realize the flow of algorithms, computing power, and data resources, based on its inherent characteristics, including decentralization, immutability, and anonymization. In addition, blockchain can guarantee the credibility of the original data as well as the audit credibility and traceability of artificial intelligence. Moreover, blockchain can record the decision-making of artificial intelligence, which helps to analyze and understand the behavior of artificial intelligence and ultimately promotes the decision-making of artificial intelligence, making it more transparent, explainable, and trustworthy. Artificial intelligence can optimize the construction of the blockchain to make it more secure, energy-saving, and efficient.

II. ARTIFICISAL INTELLIGENCE TECHNOLOGY

Artificial intelligence technology started in 1956 and has experienced three peaks of development from 1956 to 1970,

1980 to 1990, and 2000 to the present. The proposal for machine learning in 1959 promoted the peak of the first development. The United States and Japan were dedicated to artificial intelligence research in the 1980s and 1990s which promoted the peak of the second development. Benefiting from the breakthrough of deep learning and reinforcement learning algorithms, the exponential growth of network data and the qualitative leap in computing power, artificial intelligence has entered the third period of rapid development [19, 20]. Artificial intelligence includes the following key technologies: computational vision technology, natural language processing technology, cross-media reasoning technology, intelligent adaptive learning technology, swarm intelligence technology, autonomous drone system technology, smart chip technology, and brain-computer interface technology, which can be widely used in various industries, such as healthcare, driverless cars [21], education development, games, entertainment, Internet of Things [22, 23], maritime Internet of Things [24, 25], and communication networks [26, 27].

III. BLOCKCHAIN TECHNOLOGY

A. Concept of Blockchain

Blockchain technology is a kind of distributed ledger technology that stores data in a chain data structure. It is a new distributed infrastructure and computing paradigm, which employs the distributed node consensus algorithm to verify the transaction data and further synchronize the entire network, as well as uses cryptography to ensure data security and credibility [28].

B. Characters of Blockchain

B.1. Multicenter

The blockchain adopts distributed decentralized storage, so the distributed recording, storage, and update of data can be realized without a single central point. Since there is no centralized hardware or management organization, any node can operate on the data on the blockchain according to the established rules.

B.2. Transparency

The system data of the blockchain is open and transparent, and any node can have a general ledger of the entire network. Except for the private information of the directly related parties of the data being encrypted through asymmetric encryption technology, the blockchain data are open to all nodes, so the entire system information is highly open and transparent.

B.3. Autonomy

The blockchain system has multiple participants, and they have formulated automatically negotiated specifications and protocols based on open rules and algorithms. Each node in the system always follows these specifications and protocols during operation. This ensures that every transaction in a trustless environment can guarantee its correctness and authenticity. The nodes can securely exchange, record, and update data, and operations that do not follow the specifications and protocols will not take effect.

B.4. Immutability

After the transaction information of the blockchain passes the consensus of all nodes and is recorded in the block, there is a complete backup locally on each node. At the same time, the correlation between blocks is carried out by the hash algorithm. If you want to tamper with a piece of data, you need to modify all subsequent blocks, which is very costly.

B.5. Traceability

Each node in the blockchain saves all the records in the history. Any piece of data can be found by traversing the local blockchain data, which makes all the data on the blockchain chain traceable.

B.6. Programmability

The nature of the blockchain provides a trusted application environment for the execution of smart contracts, so the blockchain can provide users with programmable data manipulation capabilities. Users can customize smart contract rules that meet their needs. At the same time, due to its open and automatic execution characteristics, it also guarantees the security of assets and data on the chain.

C. Concept of Blockchain

The rich application scenarios of blockchain are basically based on the four core technologies of blockchain, namely, consensus mechanism, data structure, cryptography, and distributed storage. As the key future research direction of blockchain technology, cross-training technology has gradually become one of the core technologies of blockchain.

C.1. Consensus Mechanism

To ensure that nodes are willing to take the initiative to keep accounts, the blockchain has formed an important consensus mechanism. Common consensus mechanisms are as follows: (1) The proof of work mechanism (PoW) is the original consensus mechanism, and all participating nodes compete for bookkeeping rights by comparing computing power. Since everyone participates, but only one node can be selected, many resources and time costs will be wasted. (2) For the proof-of-stake (PoS) mechanism, the longer you hold the digital currency and the more assets you hold, the more likely this mechanism is to obtain the right to bookkeeping and rewards, which saves time but easily causes the Matthew effect. (3) The delegated proof-of-stake mechanism (DPoS)

selects representative nodes for proxy verification and accounting, which is simpler and more efficient, but it also sacrifices some decentralization to a certain extent.

C.2. Data Structure

The blockchain is similar to an iron chain in form, consisting of one block after another to form a complete chain. Each block includes a block header and a block body. The blocks are linked back and forth through the hash pointer in the block header. The hash value contained in each block header is similar to a digital fingerprint of all the data in the previous block, so there is an interlocking connection between each block. This relationship forms a chain. When any data in the block are modified, all subsequent hash values will change. Such a structure and content constitute the entire blockchain.

C.3. Cryptography

Blockchain uses killer feature-cryptography. The symmetric encryption is equivalent to using the same key to open and lock the door. Asymmetric encryption is equivalent to using a pair of different keys to open and lock the door, namely, public key and private key. If you use the public-key encryption, you can use the private key to decrypt; if you use private-key encryption, you can use the public key to decrypt. These two keys are generally stored in the user's personal wallet. Once the private key is lost, the assets are gone. It is relatively safe in the blockchain in which the public key and private key are formed through multiple transformations, and the characters are relatively long and complex [29].

C.4. Distributed Storage

The most attractive thing about blockchain is its distributed storage mechanism. The information record on each block in the blockchain is recorded by each node participating in the bookkeeping competition. To prevent some malicious nodes from doing damage, the new data in the blockchain that adopts the PoW consensus mechanism need to be unanimously confirmed and agreed upon by most nodes, and at least 51% of the nodes must agree. Therefore, it is difficult to tamper with data.

C.5. Cross-Chain Technology

Cross-chain technology is an important technical means for blockchain to realize interconnection and improve scalability. In terms of network morphology, blockchain is different from the Internet. The latter supports one network to connect to global nodes, while the former forms multiple isolated parallel networks. In addition to the extensive coexistence of public chains, private chains and consortium chains allow different organizations to have their own blockchains and even allow multiple blockchains to run simultaneously within the same organization. The number of global blockchains is increasing, and the isolation of different blockchain networks makes it impossible to effectively carry out operations, such as digital asset transfer and cross-chain communication between chains. In the cross-chain process, the two most important things are: The first is to recognize atomicity, that is, cross-chain transactions either happen or do not happen, so that honest nodes will not be damaged; the second is to ensure that the total assets on each chain will not decrease.

IV. FEASIBILITY ANALYSIS OF THE INTEGRATION OF BLOCKCHAIN AND ARTIFICIAL INTELLIGENCE

The combination of artificial intelligence and blockchain is complementary. Blockchain provides a trustworthy foundation for artificial intelligence, and artificial intelligence provides the landing conditions for blockchain.

A. Blockchain Empowers Artificial Intelligence

A.1. Transparent and Reliable Data Sources

To more securely share data among multiple organizations, it is particularly important to ensure the transparency and reliability of data sources. Smart blockchain technology ensures the transparency of data on the chain through the synchronization of the full ledger of the nodes and ensures the traceability of data through transaction signatures and time stamps and so on after certificate authentication. A transparent and reliable information-sharing channel has been constructed among multiple participants.

A.2. Strong Fairness Guarantee

The traditional blockchain system rewards miners who work hard for the normal operation of the system through tokens and promotes the good operation of the system by ensuring fairness. The party who misbehaves in multiple parties will be punished economically, and the honest party will be compensated accordingly. Smart blockchain technology ensures that system participants can obtain corresponding rewards as long as they honestly abide by the agreement through automatically executed preset smart contract codes. At the same time, the condition-triggered automatic transfer mechanism is used to distribute the rewards to the corresponding participants, which provides a strong fairness guarantee for the intelligent scene of multiparty participation.

A.3. Efficient Autonomy

As a distributed ledger technology, the main feature of blockchain is decentralization. Decentralization means that there is no authoritative center or server to manage the entire system, so the blockchain system will not be controlled by a single organization. Using the automatic execution characteristics of smart contracts, predefining management rules in smart contracts can reduce the uncertainty and possible attacks brought about by the human operation process [30, 31].

A.4. Privacy Protection

As increasingly more data content is shared on the chain, the privacy of users may be directly or indirectly leaked [32]. Traditional blockchain systems use pseudonyms, shuffling, and other methods to protect users' privacy, but malicious attackers can nevertheless steal users' private information through data mining and analysis. In the new smart blockchain system, some cryptographic technologies with excellent security performance are used to protect users' data privacy. Li et al. [33] proposed a privacy protection scheme based on ring signatures using an anonymous signature method based on an elliptic curve encryption algorithm to protect privacy. Cai et al. [34] provided a privacy protection scheme based on Pedersen's commitment for the deletable blockchain system, which can hold users accountable when necessary while protecting privacy. The Prada-Delgado team [35] used zero-knowledge proof technology to identify the Internet of things devices in the smart blockchain system, which can protect the data privacy of lightweight devices efficiently and at low cost.

A.5. Distributed Computing Power

Artificial intelligence is usually provided by a single unit of computing capacity or computing platform. With the rapid increase in the amount of data and the obvious increase in computational complexity, it is difficult for traditional computing platforms to independently provide the computing capacity required for artificial intelligence, and the hardware costs and maintenance costs of enterprises are also rising [36]. Blockchain realizes the decentralization of computing capacity with its distributed nature, which is helpful to realize the operation of artificial intelligence models on global mass decentralized nodes and realize decentralized computing. Lin et al. [37] propose a new wireless edge intelligence framework to achieve stable and robust edge intelligence through energy collection methods on a permissioned edge blockchain, and design the optimal edge learning strategy to maximize the efficiency of edge intelligence.

B. Artificial Intelligence Empowers Blockchain

The design and operation of blockchain involves thousands of parameters, as well as the trade-off of security, throughput, decentralization, and other parameters. Artificial intelligence technology can simplify these decisions and optimize the blockchain to achieve higher performance and better governance. Moreover, artificial intelligence can also improve the intelligence of blockchain applications and reduce errors caused by human influence.

B.1. Security

As we all know, unless the adversary owns the majority of mining rights, blockchain is almost impossible to hack. Unfortunately, the programs and functions of decentralized applications built on the blockchain platform are not so secure. For example, in the DAO incident [38], hackers took advantage of loopholes in smart contracts to repeatedly withdraw funds, resulting in a loss of $50 million. Artificial intelligence technology provides new development opportunities for the intelligentization of blockchain system security protection and can provide security and technical support for the entire life-cycle of blockchain transactions. As far as the security of smart contracts is concerned, some work has been done. Raja et al. [39] have used artificial intelligence technology to automatically generate smart contracts, so as to reduce the vulnerability of smart contracts as much as possible. Furthermore, data mining and other technologies are used to analyze the vulnerabilities of the smart contract, and big data analysis is used to check malicious vulnerabilities to avoid economic losses caused by hackers. The involvement of artificial intelligence in the blockchain can make smart contracts more intelligent and efficient, allowing them to form a more complete code through continuous learning and practice and reshape the capabilities of blockchain smart contracts.

B.2. Efficiency

In the industrial sector, a large number of mature blockchain systems have been put into practical application, and more enterprises are increasing investment in the application of blockchain. However, due to the limitation of data storage mode, the blockchain system generally faces serious problems of simple query function and low query performance. The reason is that the underlying data storage systems of most blockchain systems use levelDB, a data storage system designed for write-intensive applications. At the cost of data reading performance, writing performance has improved. With the increase of data and the expansion of applications in blockchain systems, it is often necessary to deal with frequent queries. The underlying storage system has excessive writing performance but insufficient reading performance, which has become the main bottleneck limiting the query performance. The data-storing methods of blockchain can likewise be enhanced with the assistance of AI algorithms. Gawas et al. [40] propose an AI-based novel TTA-CB protocol to establish a secure and distributed blockchain for data management in VECONs and utilize a PSO algorithm to solve the optimal data provider selection problem. Artificial intelligence technology has brought new opportunities for the development of blockchain. Through continuous learning and practice, it has significantly improved the speed of data query and the efficiency of blockchain applications.

V. CONCLUSION

As two most cutting-edge technologies, blockchain and artificial intelligence have the corresponding integration opportunities in addition to their own advantages, which can completely revolutionize the information technology in the future. In this paper, we introduce the background knowledge of artificial intelligence and blockchain in detail, conduct an in-depth analysis of the feasibility of the integration of blockchain and artificial intelligence, and comprehensively

summarize the research work on the integration of blockchain and artificial intelligence in the domestic market and overseas. Finally, we point out the promising application scenarios and future work.

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