Exploration on the Fusion of Artificial Intelligence and Blockchain

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Abstract. Blockchain and artificial intelligence (AI) are the two leading technologies in the world, which promote the development of the Fourth Industrial Revolution. Although there is lots of research on AI and blockchain separately, few studies focus on the fusion or integration of these two. To address this gap, this study aims to characterize the necessity and benefits of the fusion of AI and blockchain. First, we introduce AI and blockchain technologies roughly. Then, we analyze the general fusion mechanism for AI and blockchain and its necessity. Next, we carry out the critical point analysis one by one for the fusion of AI and blockchain. The detailed analysis shows that AI and blockchain technologies can enhance each other and it is wise to integrate their benefits.

Keywords: AI · Blockchain · Smart contracts · Data · Computing power · Algorithms

1 Introduction

Nowadays, we have witnessed that AI and blockchain are the two leading technologies worldwide, and they have attracted wide attention in both academia and industry [1]. Among them, AI technology is an essential driving force to promote the development of the real economy, which has brought numerous open innovations and made itself rise to the national strategic level. At the same time, emerging blockchain technology has been listed in the national informatization planning of countries around the world, whose technological development promotes a new round of industrial innovation and constantly improves the industrial advantages in emerging fields.

As two technological trends, blockchain and AI have their own distinctive features, and the focus of these two, as well as their development, also varies. In essence, blockchain technology generates and stores data through consensus algorithms, operates data through smart contracts, and ensures data security through cryptography. Blockchain technology has the characteristics of decentralization, ensures data not be tampered with, and focuses on maintaining accurate records, authentication and execution. While AI technology involves three key points, namely data, algorithms and computing power. It facilitates mining, evaluation and understanding of certain patterns in real-life industrial datasets, makes decisions based on them, and results in autonomous interactions. On one

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hand, both blockchain and AI have common characteristics and technical areas, which will be the key to their integrated development. On the other hand, each has its own strengths and weaknesses, and there is a chance for them to complement each other. In this paper, we try to explore the possibility of leveraging the benefits of blockchain and AI together at different levels, e.g., data, algorithms, computing power, and so on. After extensive analysis, we want to prove that, through their fusion, a disruptive impact will be exerted on the technology industry in all areas of society.

2 AI and Blockchain Technology Overview

2.1 AI Technology Overview

The term "artificial intelligence" was proposed at the academic conference held by Dartmouth University in 1956, when was deemed the starting point of global AI research. According to Dr. Norvig, AI can be seen as an intelligent agent designed by human beings, which refers to any system that perceives its environment and takes actions that maximize its chance of achieving its goals [2]. AI is not a new term, but a research field that has experienced decades of ups and downs. In March 2016, the world Go champion, Li Shishi, was defeated by AlphaGo with a score of 1:4, which event has ignited the world since then. In the following years, DeepMind Inc. Released several new versions of AlphaGo robots, including AlphaGo Zero, AlphaGo Master, etc. which need less training time and own higher intelligence. The resurgence of AI technology is due to the support of intelligent hardware development and new breakthroughs in machine learning (ML) and deep learning (DL).

ML is a technology that allows computers to reason without explicit programming, which is the best way to develop high-level AI. Traditional ML technology relies on the experience of domain experts to extract features. In contrast, DL technology that has emerged in recent years is a representation learning method with multi-layer neurons, which allows the machine to input raw data and automatically learn the required representation from the data. It accomplishes this task by combining simple but non-linear modules, in which each module transforms a lower-level representation into a higher and more abstract representation. Due to this characteristic, DL is very good at discovering complex structures in high-dimensional data.

Apart from the positive aspects, AI's rapid progression also causes a series of concerns. For example, AI has brought lots of trepidations, such as fake news with realistic but fake photographs or voices, invasions of privacy etc. Data, computing power and algorithms are AI's three core elements. As the "raw materials", multi-source, real-time, massive and multi-type data are the basic support to ensure high-quality models trained by intelligent algorithms. Computing power is the "booster" to achieve large-scale computing of intelligent algorithms. The acceleration of computing power such as GPU is an important infrastructure to promote the training and reasoning efficiency of intelligent algorithms. And, algorithms are the "power" to realize intelligence, which solves problems through iterative computing and brings innovations to current technologies and thinking mode. Therefore, data, computing power and algorithms are called the Troika of AI. However, the cost of computing resources along with the high barriers to acquiring data and talent could lead to the monopolization of AI power among the big players.

2.2 Blockchain Technology Overview

Since the publication of the Bitcoin White Paper in 2008, blockchain as the underlying technology of bitcoin has received extensive attention and discussion. According to Wikipedia, a blockchain is essentially a growing list of records linked and protected using cryptography [3]. The recorded unit is called a block, and each block contains a hash pointer (as a link to the previous block), a timestamp, and transaction data. Blockchain is inherently resistant to data tampering. It can be used as an open distributed account book and can effectively and permanently record transactions between both parties. All transaction records are traceable and verifiable. Simply put, blockchain is a set of protocols and a set of specifications, rather than specific codes or projects.

Blockchain can be described from a narrow or broad perspective. From a narrow perspective, a blockchain is a chain data structure, which is composed of several data blocks connected in sequence according to time. Its chain structure and the adopted cryptology technology ensure that the data can't be tampered with and forged. So, the blockchain can be regarded as a distributed ledger. From a broad perspective, blockchain technology is a pioneering distributed infrastructure and computing paradigm involving a variety of technologies. The data structure, distributed consensus algorithms and cryptology algorithms adopted by it provide guarantees for storage and verification, generation and update, security and non-tampering of data.

In a broader sense, blockchain functions through an underlying framework which can be subdivided into six independent but inseparable architecture layers, namely, the data layer, the network layer, the consensus layer, the incentive layer, the contract layer, and the application layer. The data layer manages the data record types and data structures, and specifies the data composition of the block; The network layer provides networking, message propagation, message verification and other functions for nodes in the network based on decentralized technologies; The consensus layer enables peer nodes in the decentralized network to reach a consensus on the consistency of the content; The incentive layer provides rewards for the consensus nodes to ensure the normal operation of the blockchain system; The contract layer encapsulates programmable application codes such as automation script and smart contract; The application layer provides various applications, such as digital cryptocurrency represented by bitcoin. In some layers, high-level intelligent computing techniques are needed.

3 Analysis on Fusion Mechanism for AI and Blockchain

Based on data, AI mines knowledge from data, while blockchain is essentially a data storage method, or "hyper ledger", which supports the realization of data intelligence. And blockchain technology can ensure reliable data to a certain extent, share data under the condition of protecting data privacy, provide high-quality data for AI modeling, and thus improve the accuracy of the model. Therefore, the two technologies that are closely related to data can be effectively combined to complement each other and achieve technological upgrading (Fig. 1).

Blockchain technology has the characteristics of being distributed, open, transparent, traceable, and difficult to tamper with. It can improve the authenticity, relevance and effectiveness of data used in AI applications by combining multiple technologies, such

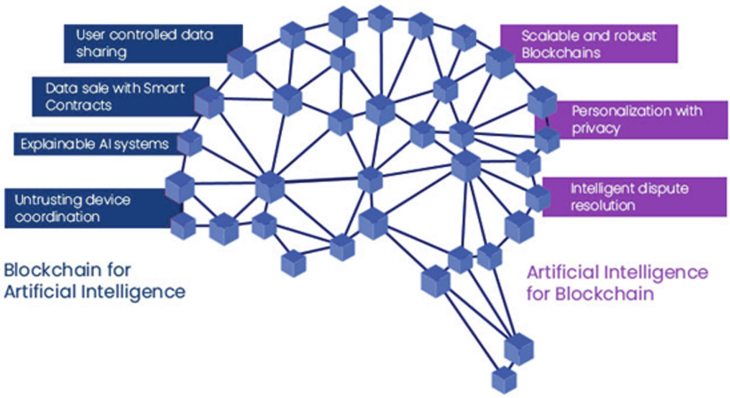

Fig. 1. Integration of AI and Blockchain [4].

as distributed data storage, point-to-point transmission, consensus mechanisms, and encryption algorithms. Also, it can ensure the intelligence level of AI models in three different aspects, i.e., data, computing power and algorithms, innovate the collaborative mode and computing paradigm of AI technology, and build a new AI ecosystem. Based on the blockchain, AI can realize decentralized intelligent joint modeling and provide users with flexible computing capabilities to meet specific application needs.

The smart contract in a blockchain is essentially a piece of code that implements a certain algorithm, which can be made more intelligent by AI technology. AI has the characteristics of being intelligent and automatic. Through optimization and simulation, AI algorithms can promote the natural evolution and data sorting of the blockchain, effectively prevent the occurrence of bifurcation of linked nodes, and more efficiently handle the operation of the blockchain. For example, AI algorithms can transform traditional contracts into smart contracts, effectively solving the problems of security, ease of use and reliability. At the same time, decentralized learning systems such as "joint learning" introduced by AI can be used to solve the problem of redundant information on the blockchain, which can improve the extensibility and efficiency of the blockchain.

Given their interdependence with each other, There's no reason not to believe it will be a good idea to fuse AI and blockchain technologies. In the following section, we will conduct a detailed analysis of their integration from different levels and aspects.

4 Key Points Analysis for Fusion of AI and Blockchain

4.1 Data Level Analysis

At present, massive data in the AI industry lacks a unified and efficient sharing mechanism and management method. The poor maintenance of open-source datasets leads to uneven data quality with the data being not centralized and unified. Additionally, a large amount of data required for model training are mainly available only in the government and large companies. The regulatory restrictions and high commercial threshold lead to

poor data circulation and difficult access, which seriously restricts the pace of small and medium-sized enterprises in developing AI applications. And, when an intelligent agent is going to make a decision, it needs to obtain as much real-time data as possible to be a reference. If there is not enough real-time data or the data is not real-time enough, then this agent can only achieve limited intelligence. Moreover, due to the poor quality and credibility of raw data and the invasion of personal privacy, the authenticity, timeliness and credibility of the data in the big data trading market are greatly reduced.

The distributed database in a blockchain enables each node to share data efficiently so that each participant on the network can access data, which provides more extensive data access and a more effective data monetization mechanism for AI [5]. Firstly, a decentralized data-sharing platform can be built based on blockchain technology. Its updating and information recording are completed by the interaction of distributed entities, not by an authority. In the network, it is not allowed to tamper with data, modify data or create false data at will. Secondly, data verification in a blockchain will promote the establishment of cleaner and more organized personal data, thus providing smoother data integration and forming a new data market. Based on homomorphic encryption, zero-knowledge proof, differential privacy, and other technologies, data privacy security protection in multi-party data sharing is realized. Finally, the incentive mechanism and consensus mechanism based on blockchain technology have greatly expanded the source channels of data acquisition. More open, shared and real-time data for analysis will make the prediction and evaluation by AI more accurate, generate more reliable algorithm models, and then improve the technical level of the whole AI model.

4.2 Computing Power Level Analysis

The cost of computing power is a big pain in the current AI industry. As data grows exponentially and algorithms become more and more sophisticated, AI models have reached the scale of hundreds of billions of parameters trained on trillions of training data samples, which undoubtedly requires stronger computing power. It needs more than one million yuan to purchase GPU and other hardware resources to build a computing center, which is too expensive for most small and medium-sized enterprises, resulting in the current situation of "insufficient computing power, high cost and difficult to obtain". According to an analysis report [6] released by OpenAI, since 2012, the amount of computing required to create the most advanced AI system has increased 10 times every year, and computing power has become a major bottleneck in the development of AI applications.

Distributed computing in the blockchain can use idle GPUs of small, medium-sized enterprises or individuals as computing nodes to share computing resources and provide computing power for AI modeling. For example, through blockchain technology in Xunlei Inc., users can share idle resources such as bandwidth, storage and computing capacity through Xunlei cloud devices [7]. Although the computing power of each device is very small, when the number of devices reaches a certain magnitude, the accumulated computing power is also huge. Based on the distributed network, the blockchain helps to build a decentralized AI computing infrastructure. It can realize the operation of neural network models on the decentralized massive nodes distributed around the world,

make use of the idle computing resources of each node for computing, realize decentralized intelligent computing, and change the traditional idea of constantly improving the performance of equipment to improve computing power. In addition, through the smart contract, computing nodes in the network can be dynamically adjusted according to the computing amount of the user's applications, so as to provide flexible computing capacity to meet the user's specific needs.

Mining the blockchain requires lots of computing resources and power. At present, the annual power consumption of bitcoin is about 2.55 billion watts, almost equivalent to the annual power consumption of some small countries. Applying AI techniques to POW consensus mechanism and hash operation can greatly improve calculation efficiency, thus saving power and energy. For example, Matrix, a start-up enterprise, uses AI to combine POW and POS and adopts a hierarchical consensus mechanism. First, it uses random clustering algorithms to generate multiple small clusters in the network and elects representative nodes based on POS mechanism. Then, the elected nodes compete for POW accounting rights. Compared with the competitive accounting method involving all the nodes, it can greatly reduce energy waste. Besides, the intelligent system can calculate the probability of a specific node performing tasks first, so as to remind the miners to find other paths and reduce the total operation cost. Additionally, optimizing energy consumption techniques in AI can also be applied to the blockchain, thereby reducing the investment in mining hardware.

4.3 Algorithm Level Analysis

Nowadays, there is a large demand for AI technology in the market. However, at the algorithm level, the threshold of AI algorithm research and development as well as the requirement for talent teams are high. The current algorithms can only meet the needs of a few enterprises. The development of personalized products has high technical and financial barriers, which makes it extremely difficult for most enterprises to develop AI independently. In such an information-explosive era, the construction and sharing of information resources have become the need and necessity of the times. Now, advanced AI development tools are only in the hands of a few people. For example, the programming community created by independent researchers can't be installed, configured and run by the outside world, and their algorithms and models can't be accessed. Information island and interception have become the biggest barrier to resource sharing. Additionally, most enterprises obtain open-source algorithms from the open-source community, but there are many rules or version adaptation problems, which seriously limit the flexibility and innovation of application development. When hosting or contributing code in the open-source community, improper management of proprietary intellectual property code may cause the risk of property disclosure.

With the characteristics of distributed collaboration of blockchain, a platform for releasing ML tasks can be built. AI algorithms can be optimized, updated and maintained by multiple AI experts to realize algorithm sharing. Blockchain can bring an open AI development mode to allow more people to participate and share AI resources, which is conducive to improving resource utilization and AI's long-term development [8]. Additionally, an algorithm trading market can be built based on blockchain technology, allowing users to publish tasks and purchase algorithm models on the platform,

encouraging developers, and greatly reducing the threshold of AI use under the condition of ensuring intellectual property rights and privacy. The AI + blockchain can encourage developers of AI models to share their development achievements.

4.4 Intelligence + Contract

The emergence of blockchain technology redefines traditional contracts, which further details and deepens the connotation of smart contracts. Current smart contracts are generally coded programs that have status, are event-driven, comply with certain protocol standards, and run on the blockchain. It can process and operate the blockchain data in the form of events or transactions under certain triggering conditions according to the code rules, and thereby control and manage the digital assets of the blockchain network. As an embedded programmed contract, it can be built into any blockchain data, transactions, and tangible or intangible assets to form a programmable controlled software-defined system, market and assets.

A smart contract is only a system composed of transaction processing modules and state machines. It exists only to enable a group of complex digital commitments with trigger conditions to be correctly executed according to the will of participants [9]. In addition, smart contracts are not legally binding, nor functionally smart. In the case that commercial activities really need to actually sign contracts, smart contracts can't realize the functions given by their names in practice and theory. The smart contract code itself also lacks the basic elements of real contracts, such as terms, conditions and dispute resolution. Smart contracts still have a long way to go before they are truly legally binding. Smart contracts have security problems easily exploited by hackers, and human intervention makes their vulnerability unable to be repaired online, ending in more serious problems or chain reactions [10]. In addition, due to the non-tamperability and upgrading particularity of smart contracts, they are actually only a series of deterministic and complex results fed back based on different inputs. Not only that, the code of smart contracts is rigid and invariable, and lacks necessary flexibility in practical applications. Therefore, current smart contracts are not smart, whose processing is deterministic.

AI brings good news to the relatively rough smart contract technology in blockchain and helps to realize contract intelligence. First, AI combined with smart contracts can quantitatively deal with problems in specific fields and make smart contracts own certain prediction and analysis capabilities. For example, in the application of insurance anti-fraud, the risk control model is built based on AI technology, the anti-fraud prediction is carried out through the data combination of different telephone numbers of operators, and the corresponding processing is carried out according to the rules of the smart contract. AI-based smart contracts can handle financial risks that can't be predicted by human beings, and it has advantages over mankind in credit rating and risk pricing. Second, the intervention of artificial intelligence makes it have the ability of bionic thinking evolution. As far as the smart contract itself is concerned, through the AI engine, under the guidance of the template and wizard program of the graphical interface, the user input can be converted into complex smart contract code, that is, the "Smart Protocol" that conforms to the user and the business scenario can be generated. Third, AI constantly forms public computing power through learning and application practice. Of course, the deep integration of AI and smart contracts needs to overcome both legal and

technical difficulties. Although some relatively simple contracts can usually automate the performance, human intervention may be required to resolve disputes for more complex contracts.

5 Conclusion

In this paper, we analyzed the advantages and disadvantages of AI and blockchain from different levels of data, algorithm and computing power etc., and explore the necessity and benefits to fuse AI and blockchain and make them complement each other. Through extensive analysis, it can be seen that blockchain and AI can mutually empower each other and it is a good idea to integrate them.

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