An Analysis on the Application of Machine Learning in Bitcoin

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Abstract:

The rapid development of Bitcoin and blockchain technology is shocking. In the development of Bitcoin and other industries, machine learning has contributed a lot and has unlimited potential. It can not only analyze the data in the transaction process, but also bring security and predict the development trend of the market. The combination of multiple technologies promotes the efficiency of Bitcoin transactions, and provides effective support for making correct decisions, which is enough to show that financial technology can still undergo unpredictable changes in the next stage of development. In this research, the application of machine learning technology in the development of Bitcoin is analyzed in depth, especially in improving efficiency, improving intelligent contracts, monitoring transactions and so on. Through the analysis, efficiency and prediction accuracy of the model will change positively because of the application of algorithm and data processing technology. This study also points out the significance of protecting user privacy and enhancing data security, which brings effective strategies for the development of Bitcoin technology, the wide use of encryption technology and the improvement of regulatory efficiency, and fully taps the potential of machine learning.

Keywords: Machine learning; Deep learning; Bitcoin; Blockchain; Smart Contracts.

1. Introduction

Bitcoin is a decentralized digital currency that uses blockchain technology to ensure transaction security and transparency. Its total supply is limited to 21 million, and transactions are generated and processed through mining. Due to transaction anonymity, limited supply, and price volatility, Bitcoin gained widespread acceptance over time, and despite its challenges, it remains the most well-known cryptocurrency. For decades the trust issues during transaction have prompted high cost of mediation fees and services for its irreversibility [1,2]. Nakamoto introduced a cryptographic proof-based electronic payment system, known as blockchain, as an alternative to relying on trust. Its advantages of low transaction risk, lower transaction fees, faster transaction speed, and not susceptible to inflation leads to increasing acceptance [2]. Unlike traditional finance, Bitcoin is a decentralized and peer-to-peer system based on blockchain technique [1]. Related research shows that, until March 23, 2024, the value of Bitcoin transactions exceeded $39 billion daily. The sheer size of the market capitalization demonstrates Bitcoin's dominance among global crypto assets and its relative importance in investors 'diversified portfolios. (https://coinmarketcap.com). However, Machine learning is mainly used in transaction monitoring and fraud detection, market trend prediction, mining efficiency optimization, and in-depth analysis of blockchain data in the Bitcoin ecosystem, aiming to improve transaction security, predict market fluctuations, and improve mining efficiency. efficiency of the mining process, as well as enhancing the transparency and supervision of the blockchain. Although Bitcoin faces problems such as scalability, high transaction fees, high energy consumption, and security and regulatory challenges, these problems can be alleviated to a certain extent by combining advanced technologies such as machine learning, thereby improving the overall performance of the Bitcoin network, user experience.

This article aims to summarize some applications of machine learning in the Bitcoin field and explore these technologies' limitations and development potential. Section 1 will briefly overview the current status of research and application of machine learning in the field of Bitcoin. Section 2 will analyze several ML technologies and corresponding theoretical support in detail. Section 3 will put forward the limitations of these technologies, make targeted suggestions based on areas with development potential, and predict future development trends.

2. Machine learning

Machine learning is a subset of artificial intelligence. It is a field of data science about the research and development of algorithms and statistical models to bestow on comput-

er systems the ability to learn from data and generalize decision-making capabilities without explicitly programming in advance. Specifically, training a model to analyze data and make decisions involves a large data set (training data) input into an algorithm for future identification of underlying patterns and rules in the data. After the training phase, the model is available for new data that has not been seen before to perform prediction and classification tasks, which is called inference [3].

When confronted with large volumes of data, ML models output recognizable trend and pattens for wide-ranging applications. Otherwise, ML models perform well at handling multi-dimensional and multi-variety data with continuous improvement. It is worth mentioning that these tasks could be accomplished without human intervention [4]. The preprocessed and analyzed data offers conveniences for human, enabling them to engage in social development. Machine learning revolutionizes health, industry, transportation, marketing, and other fields by developing robots to perform dangerous tasks, detect diseases like cancer and glaucoma early, visualize smart cars, improve web searches, language translation, and more [5]. If humans wish to apply machine learning more reasonably and comprehensively in the future, they must clearly understand advantages and disadvantages of machine learning [4]. In recent years, the intersection of machine learning (ML) and fintech has given birth to transformative applications, especially in cryptocurrencies such as Bitcoin. Despite various machine learning techniques already being applied in industries, several drawbacks still needed to be solved. Data acquisition, time and resources, interpretation of results, and high error-susceptibility are areas in which humans try to improve.

3. Machine Learning in Bitcoin

3.1 Current situation

The application of ML in Bitcoin is gradually growing. Despite its current lack of popularity and full maturity, its contribution and potential to the Bitcoin ecosystem should not be ignored. In terms of transaction monitoring and fraud detection, ML technology has been well-developed and effectively improves the security of the Bitcoin network by analyzing transaction patterns to identify potential illegal activities or abnormal behaviors [6]. However, in market analysis and forecasting, ML models exhibit promise analyzing market trends and predicting price variations. However, the accuracy of ML models is constrained due to the market's inherent unpredictability, which is an ongoing area of investigation. For Bitcoin at this stage, the importance of ML is mainly reflected in improving transaction security [6], supporting investment decisions [7], and improving network efficiency [8]. In addition, while machine learning is still in its early phases of use in mining optimization, machine learning has the potential to further enhance the overall performance of the Bitcoin network by improving the efficiency of computing power utilization and reducing energy consumption [9].

3.2 Applications

3.2.1 Price Prediction

Although Bitcoin is essentially different from traditional stocks, securities, and futures, as a digital product with high volatility and limited supply, Bitcoin is widely chosen as an investment tool. Given the effectiveness and feasibility of machine learning in predicting traditional financing markets, machine learning's predictions in the Bitcoin market are also available for reference.

Luisanna Cocco, Roberto Tonelli, and Michele Marchesi explore the effectiveness of using different machine learning models to predict Bitcoin prices. The study primarily assesses the efficacy of Bayesian Neural Network (BNN), Feedforward Neural Network (FFNN), Long Short-Term Memory Neural Network (LSTMNN), It specifically highlights the two-stage model combined with support vector regression (SVR) in processing this problem. Superiority in class prediction. The study rigorously evaluated the model through the k-fold cross-validation method. The results demonstrated that although the single-stage model worked satisfactorily, the two-stage model, especially the model containing BNN, exhibited superior predictive accuracy. This research showcases the significant capabilities of machine learning technology in financial market prediction. It also provides an empirical foundation for financial technology applications in the high-volatility cryptocurrency market. This enables investors and market analysts to develop effective trading strategies.

As an important statistical method, one of the advantages of time series analysis is that it can arrange data points in chronological order, understand the law of development and change, and identify irregular components [10]. Time series can play an important role in environmental science, economy, finance and other fields, and can reasonably predict the next development. The extensive use of advanced statistical techniques, especially a series of analysis models, can contribute greatly to the effectiveness of time series, extract reasonable insights from historical data, predict the development of climate change and financial markets, and grasp the development direction of several key variables. Mohammed Hamoud [11] used this statistical method to conduct a comprehensive study of Bitcoin during his research and gave full test to the role of a variety of machine learning models, including feedforward neural networks, Bayesian neural networks, and so on.

In the process of research, scholars are fully aware that in order to solve a series of problems exposed in the development of Bitcoin, including non-stationarity and large price fluctuations, more complex algorithms are needed to reflect the high-dimensional characteristics, but it is difficult to deal with these problems only by using traditional prediction models. The prediction accuracy can be improved by using time series.

In order to improve the prediction accuracy significantly, it is necessary to play the role of optimization equation, so as to obtain a more effective machine learning model, which requires the determination of appropriate parameters. Chen et al. [12] made an in-depth analysis of which machine learning method should be chosen to predict the price of Bitcoin. In this study, team members use sample dimension engineering to divide price prediction into daily price and high frequency price and select the corresponding machine learning model according to the specific situation of each prediction task. Scholars agree that in the process of predicting daily prices, machine learning algorithms are more complex, but some simple statistical methods have more prominent performance, which can create 66% accuracy. When predicting high-frequency prices, it can be predicted every 5 minutes, and the more accurate is the complex model, which can reach 67.2%. Focus on the value of dimension and data frequency in the process of model selection, with the aim of improving accuracy in predicting the price of Bitcoin.

3.2.2 Optimizing Smart Contracts

Smart contracts belong to software applications, and their birth and development are inevitably related to the support of block chain technology. As long as the set standards are met, the operations defined in the contract will be initiated without the need for third party approval or instructions. Automation is the basic feature of intelligent contracts, which can resist tampering, have strong openness, ensure transaction security and improve efficiency. Intelligent contracts have been fully used in many block chain platforms, and financial and non-financial transactions have developed rapidly with their assistance, including voting systems, automatic payment and so on. As long as the smart contract code can be arranged on the block chain, it can not be changed, thus obtaining the ideal security and credibility [13]. In order to give full play to the role of block chain intelligent contract, Balaram Yadav Kasula chose to apply machine learning. The research involves three main machine learning algorithms: reinforcement learning, neural networks, and probabilistic models. Reinforcement learning is used to improve the adaptability and resource efficiency of smart contracts, particularly in optimizing the Gas consumed during contract execution; neural networks are used to enhance the security of smart contracts by identifying and preventing potential security vulnerabilities; probabilistic models are applied to improve the scalability and execution speed of intelligent contracts. The incorporation of these technologies offers fresh insights and approaches for the advancement and implementation of blockchain technology. Moreover, the research [14] comprehensively examines the application of machine learning technology in improving the security of blockchain smart contracts. The research evaluates in detail a variety of integrated machine learning tools such as Mythril, Oyente, SmartCheck, Securify, and Zeus. These technologies utilize machine learning to identify and address security flaws in smart contracts. The paper points out that combining machine learning with traditional security audit methods can significantly improve the ability to identify and defend smart contract vulnerabilities.

3.2.3 Fraud Detection and Security

Whether it is Bitcoin or several other types of encrypted currencies, security and fraud detection should be guaranteed in the process of development. The most fundamental reason is that the structure of digital currency is decentralized and anonymous, which provides favorable conditions for the implementation of illegal transactions and can lead to a series of fraudulent incidents. In order to solve this problem, experts and scholars have developed a variety of technologies to detect fraud, in order to enhance the reliability of transactions.

Chen Pinjie et al. [15] fully realized that if Bitcoin wants to achieve sustainable development, it must solve the problem of frequent theft, because Bitcoin can bring higher economic benefits. This paper argues that in order to detect the theft of Bitcoin in time, we should play the role of supervised learning method, fully grasp the characteristics of Bitcoin data, and realize the importance of extracting transaction data. In this research, a series of transaction data are collected comprehensively, the characteristics of Bitcoin are analyzed comprehensively, and the corresponding data are extracted. Through research, we know that random forest can play an important role in all aspects, whether it is evaluation or recall, and can effectively improve the detection efficiency. In order to make the model have more perfect performance, balanced training should also be carried out.

In this study [16], the two technologies of machine learning and blockchain are integrated, and multi-stage quality control is adopted to bring security assurance to the entire manufacturing process and improve the effectiveness of fraud detection. With the help of block chain technology, it creates a highly transparent and unchangeable environment, which can record relevant data comprehensively, avoid data tampering, and enhance the verifiability of

data. Machine learning algorithms are introduced into this research, especially artificial neural network, which can automatically classify the input data and predict the quality problems in advance. These can play an important role in collecting data and creating data sets, which can identify quality deviations, quickly detect abnormal behavior, achieve the purpose of effective quality control, and take effective measures according to the characteristics of fraud. By monitoring the performance of equipment and actively carrying out trading activities, intelligent manufacturing will develop in a safe and reliable direction and will also have a more prominent performance in preventing fraud.

4. Conclusion

In this research, we deeply analyze the value of machine learning technology in the development of Bitcoin, especially its specific performance in optimizing intelligent contracts and monitoring transactions.

In this research, it is further realized that machine learning technology can not only promote the safe and stable development of Bitcoin, but also promote the optimization of transactions. However, due to the limited flexibility of the model and the lack of data quality, these will have a negative impact on the validity of Bitcoin. In order to promote the improvement of prediction accuracy and eliminate these limitations, this paper emphasizes the importance of collecting data and optimizing the preprocessing process. To this end, complex data cleaning techniques can be used, and data sources should be broadened to promote data quality in a variety of ways. Ensemble learning technology can integrate traditional and advanced statistical models, play the role of in-depth learning, and significantly improve the accuracy of the prediction system. This paper argues that more effective methods should be explored to provide support for the adjustment of model parameters and enhance the adaptability of market environment. Bitcoin shows strong anonymity in the transaction process, so it is necessary to ensure data security and solve the problem of privacy disclosure. Therefore, more advanced technologies should be introduced to enhance the security performance of the model and achieve the purpose of protecting user data. The Bitcoin market is increasingly broad and has significant cross-border characteristics. In the next stage of research and development, more effective analytical tools should be found to better adapt to the policy changes of various countries, eliminate the adverse effects of economic variables, and enhance the ability to understand and predict.

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