

Construction of Cryptocurrency Price Prediction Model Based on Graph Neural Network

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Abstract: With the rapid development of the cryptocurrency market, the high volatility and complex correlation of cryptocurrency prices have had a profound impact on the security and stability of financial markets. This article proposes a cryptocurrency price prediction model based on graph neural networks. The experiment selects historical data of mainstream cryptocurrencies such as Bitcoin and Ethereum. The comparison results show that graph neural networks can effectively capture the dynamic trend of cryptocurrency prices, providing more reliable decision support for cryptocurrency market investors and regulatory agencies.

Keywords: Graph Neural Network, Cryptocurrency, Price forecast.

1. Introduction

In recent years, the cryptocurrency market has experienced remarkable growth, attracting widespread attention from investors worldwide. Since the birth of Bitcoin in 2009, cryptocurrency, as a new type of digital currency based on blockchain technology, has set off a wave of innovation in the financial sector with its decentralization, anonymity, and non-tamperability. As of the latest data in 2024, the global digital asset market is showing a thriving trend, with its overall valuation exceeding the \$2 trillion mark. The market trading activity has maintained stable growth, and various new types of encrypted assets continue to emerge. Among the mainstream digital assets, in addition to the dominant Bitcoin, other important cryptocurrencies such as Ethereum and Litecoin also play a pivotal role in the market. This development trend indicates that the digital asset market is constantly maturing and diversifying [1].

The research on digital asset price prediction has important theoretical and practical value. For market analysis institutions, establishing scientific prediction models can deeply reveal market operating rules, investor psychological characteristics, and price formation mechanisms, providing empirical evidence for improving the market theoretical system. [2] From a regulatory perspective, accurate price trend analysis can provide decision-making support for regulatory agencies, help build risk warning mechanisms, and timely identify systemic risk hazards. It is worth noting that due to the intense price fluctuations and strong anonymity of transactions in the digital asset market, this field is prone to breeding illegal and criminal activities such as money laundering and market manipulation, which puts higher demands on regulatory technology (RegTech). [3] The predictive model constructed through big data analysis and artificial intelligence technology can help regulators more effectively monitor abnormal trading behavior and maintain financial market order. Through the monitoring and prediction of prices, regulators can discover abnormal trading behavior in a timely manner, take appropriate regulatory measures and protect the legitimate rights and interests of investors [4].

Traditional financial time series analysis methods, such as ARIMA, GARCH, etc., often face many challenges when

dealing with cryptocurrency price prediction problems. These methods typically assume that data has stationarity and linear relationships, but the cryptocurrency market is influenced by multiple complex factors, including market supply and demand, macroeconomic conditions, policy and regulatory changes, technological innovation, and investor sentiment. [5] The price formation mechanism exhibits high nonlinearity and uncertainty, and traditional methods are difficult to accurately capture these complex relationships. With the rapid development of artificial intelligence technology, the application of machine learning and deep learning algorithms in the financial field has gradually become a research hotspot [6].

Graph Neural Networks (GNNs), as an important branch of deep learning, are specifically designed to process graph structured data, providing new ideas and methods for cryptocurrency price prediction. In the cryptocurrency market, the application of blockchain technology enables transaction data to naturally present a graph structure, where each transaction address can be viewed as a node in the graph, and transaction behavior forms the edges between nodes. This graph structured data contains rich information. [7] Graph neural networks can effectively capture the complex relationships between nodes in a graph. By learning node and edge features, they can uncover potential patterns and patterns in the data, providing a more accurate model for predicting cryptocurrency prices. [8] Graph neural networks can analyze trading patterns and trends in the market by learning the fund flow relationships between different trading addresses, and predict the trend of cryptocurrency prices. It can also integrate multiple influencing factors, such as market trading volume, trading frequency, macroeconomic indicators, etc., and input these factors as node or edge features into the model to improve the accuracy and reliability of predictions. [9]

2. Overview of Cryptocurrency

In 2009, Bitcoin emerged as the first decentralized cryptocurrency, marking the beginning of the era of cryptocurrency. The design concept of Bitcoin is highly innovative. It packages transaction information into "blocks" through complex algorithms and encrypts them to ensure that the data is tamper proof and traceable throughout the process, like a decentralized, digital, and highly secure "electronic

cash". [10] Since the birth of Bitcoin, various similar cryptocurrencies have sprung up like mushrooms after rain, collectively known as "altcoins". These cryptocurrencies continue to innovate and develop on the basis of Bitcoin, each with unique characteristics and application scenarios. Ethereum has added smart contract functionality to Bitcoin, allowing developers to build and run distributed applications on its blockchain; Litecoin has set the block generation time to every 2.5 minutes in order to speed up transaction processing, which is a significant improvement compared to Bitcoin's 10 minutes. [11] Nowadays, the cryptocurrency market has developed into a vast ecosystem containing

thousands of tokens, covering various types of cryptocurrencies. In addition to mainstream cryptocurrencies with high market capitalization such as Bitcoin and Ethereum, there are also different types of cryptocurrencies such as stablecoins and platform coins. Stablecoins aim to maintain price stability and are typically linked to stable assets or currencies such as USDT, USDC, etc; Platform currency is issued by a specific cryptocurrency exchange, which has special functions and uses such as trading preferences, participation in platform activities, voting rights, etc., such as BNB, HT, OKB, etc. [12].

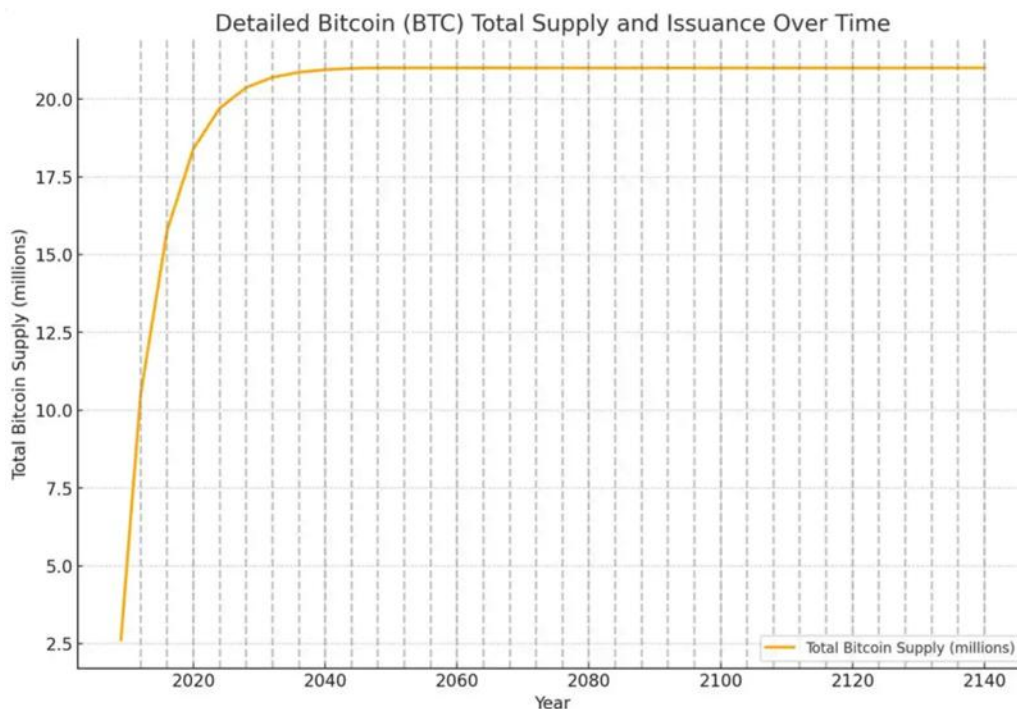


Figure 1. Detailed Bitcoin (BTC) Total Supply and Issuance Over Time

The development process of cryptocurrency is full of innovation and change, which has had a profound impact on the global financial landscape. In its early stages of development, Bitcoin, as a pioneer, faced many doubts and challenges, but with its unique decentralized characteristics and anonymity, it attracted the attention of a group of technology enthusiasts and early investors. As the blockchain is hot, its application value is being constantly speculated, attracting a large number of operator startup teams to enter the field of digital assets in an attempt to get a share of the pie, and facilitating the vigorous development of the innovation ecosystem. The second batch of blockchain platforms represented by Ether has opened up a brand new path for the application of distributed ledger technology through the introduction of the smart contract mechanism. This programmable contract system not only reconfigures the execution of traditional contracts, but also breeds a rich ecosystem of decentralized applications (DApps), whose application scenarios have been extended to diversified fields such as digital finance, cultural and recreational life, and social networks, demonstrating the strong adaptability and innovation potential of blockchain technology [13].

In recent years, the size of the cryptocurrency market has been continuously expanding, and the capital scale has reached an unpredictable level, attracting investors from all over the world to participate. The total market value of cryptocurrencies continues to expand, and trading activities

are becoming increasingly active. The development of cryptocurrency has not been smooth sailing. In terms of government regulation, due to the anonymity of cryptocurrency, regulation cannot take it into account. At present, governments of various countries have different attitudes towards them, and some governments hold a reserved attitude. Some countries actively promote the construction of relevant regulations, striving to find a balance between ensuring innovation and preventing risks; [14] However, other countries hold a cautious or even resistant attitude, concerned about the potential money laundering, tax evasion, illegal fundraising, and other issues it may bring. At the technical level, there are also many issues with blockchain technology. With the continuous expansion of user scale, these issues have become increasingly prominent, limiting the further popularization and application of cryptocurrencies [15].

The price of cryptocurrencies is influenced by a combination of multiple factors, exhibiting high volatility and complexity. The market supply and demand relationship is a direct factor affecting the price of cryptocurrencies. When the demand for a certain cryptocurrency in the market is strong and the purchase volume increases, its price often rises; On the contrary, when investors sell one after another and supply increases while demand decreases, prices will fall. Taking Bitcoin as an example, in 2021, with the influx of institutional investors and increased market recognition, the price of

Bitcoin soared to nearly \$70000 at one point; In the subsequent market adjustment, due to some investors taking profits and changes in market sentiment, the price of Bitcoin fell sharply again [16].

3. Model Building Process

The construction of a cryptocurrency price prediction model based on graph neural networks is a process that combines graph neural network technology with the characteristics of the cryptocurrency market to achieve effective prediction of cryptocurrency prices. The following are the specific construction steps:

3.1. Data Collection and Preprocessing

3.1.1. Data Collection

Collect historical price data of cryptocurrencies from multiple authoritative cryptocurrency trading platforms, financial data providers, etc., including basic information such as opening price, closing price, highest price, lowest price, and trading volume at different time intervals (such as minutes, hours, days, etc.). At the same time, collect external factor data related to cryptocurrency prices, such as macroeconomic indicators, policy news, social media sentiment, etc.

3.1.2. Data cleaning

Clean the collected data to remove data records that contain missing, incorrect, or outlier values. For missing values, choose an appropriate filling method based on the specific situation, such as mean filling, median filling, or time series based interpolation.

3.1.3. Data Standardization

Standardize data with different features to make them have similar scales and distribution ranges. The commonly used standardization method is Z-score standardization, which maps data to a distribution with a mean of 0 and a standard deviation of 1 to avoid dimensional differences between different features affecting the training performance of the model.

3.2. Feature Engineering

3.2.1. Price related feature extraction

Calculate various derivative features from raw price data, such as price volatility, returns, moving averages, etc. Price volatility can be measured by calculating the standard deviation of prices over a period of time, reflecting the degree of volatility in cryptocurrency prices; The rate of return is the percentage change in prices at adjacent time points, used to measure the return on investment; The moving average is the average value of prices within a certain time window, which can smooth the price curve and reflect the long-term trend of prices.

3.2.2. Extraction of trading volume features

Analyze the relationship between trading volume and price, extract features related to trading volume, such as the mean, standard deviation, turnover rate, etc. Turnover rate refers to the ratio of trading volume to circulating share capital within a certain period of time, reflecting the level of trading activity in the market.

3.2.3. External factor feature extraction

Extract and quantify features from collected external factor data. For example, using macroeconomic indicators such as GDP growth rate, inflation rate, etc. directly as features; For policy news and social media emotions, sentiment analysis

can be performed using natural language processing technology to convert them into numerical features such as positive emotion scores, negative emotion scores, etc.

3.2.4. Feature selection and combination

Using feature selection algorithms such as correlation analysis, information gain, etc., select features with high relevance and importance for predicting cryptocurrency prices. At the same time, different feature combinations are attempted to compare the predictive performance of the model under different feature combinations through experiments, and the optimal feature set is determined to improve the prediction accuracy and generalization ability of the model.

3.3. Model Design

3.3.1. Graph Structure Construction

Based on the characteristics of the cryptocurrency market and the relationships between data, construct the corresponding graph structure. For example, different cryptocurrencies can be viewed as nodes in the graph, and their correlations (such as similarity in price trends, correlation in market share, etc.) can be used as weights for edges. Alternatively, based on time series data, the prices and related features of cryptocurrencies at different time points can be used as nodes to connect nodes through the correlation of time sequence or price fluctuations, forming a time series graph.

3.3.2. Model Hierarchy Design

Determine the number of layers in the graph neural network and the specific structure of each layer. It generally includes an input layer, multiple hidden layers, and an output layer. The input layer converts the preprocessed data into a format suitable for graph neural network processing, and inputs node features and graph structure information into the model; The hidden layer gradually extracts advanced features from graph data through multiple iterations of message passing and feature transformation, deepening its ability to model the complex relationship between cryptocurrency prices and related factors; The output layer generates prediction results based on task objectives, such as predicting the price of cryptocurrency or the trend of price fluctuations at a certain point in the future [17].

4. Development Prospects

The development prospects of cryptocurrency price prediction models based on graph neural networks are relatively broad, mainly reflected in the following aspects:

4.1. Technological Progress Drives Performance Improvement

4.1.1. Model improvement and innovation

Researchers continuously explore new graph neural network architectures and algorithms, such as combining attention mechanisms, introducing variational autoencoders, etc., to further improve the model's ability to capture complex relationships and predict accuracy in the cryptocurrency market. For example, Graph Attention Network (GAT) can adaptively focus on the importance of different nodes and edges in the graph, thereby extracting price related features more accurately.

4.1.2. Integration with other technologies

Combining graph neural networks with other deep learning models or traditional statistical methods is an important

development direction. If combined with Long Short Term Memory (LSTM) networks, the advantages of graph neural networks in processing graph structured data and the ability of LSTM in processing time series data can be simultaneously utilized to better integrate the spatial relationships and time series information of cryptocurrency prices, thereby improving prediction performance.

4.2. Data Enrichment and Quality Improvement

4.2.1. Multi source data fusion

With the development of the cryptocurrency market, the available data sources are becoming increasingly diverse. In addition to basic transaction data, social media data, news information, macroeconomic data, etc. can be integrated into graph neural network models as supplementary information. By integrating these multi-source data, the model can gain a more comprehensive understanding of the market situation and improve the accuracy of predictions. For example, discussing the investment value and development trends of cryptocurrencies on social media can help models capture the impact of market investors' psychological price expectations on changes in investment willingness.

4.2.2. Data Quality Improvement

The continuous advancement of data collection and processing technologies helps to improve the security and public trust of cryptocurrencies. At the same time, more advanced data processing techniques and crisis preprocessing methods can reduce security crises in data, provide a higher quality data foundation for graph neural network models, enable them to learn better for popularization and development, and improve predictive performance.

5. Summary

This article focuses on the research of a cryptocurrency price prediction model based on Graph Neural Network (GNN). Firstly, the model construction process is introduced. By constructing a relationship graph between cryptocurrency trading data, market indicators, and macroeconomic factors, GNN is used to mine nonlinear relationships in the data; Then, experiments were conducted to verify that the model has more advantages in prediction accuracy compared to traditional time series models and ordinary neural network models; Finally, explore the challenges and future potential that the model faces in its development.

The opening of the paper points out the background of complex price fluctuations and difficulty in accurate prediction in the cryptocurrency market, and proposes the core goal of constructing a GNN based prediction model. During the research process, empirical analysis confirmed the effectiveness of the model in capturing the dynamic trends of cryptocurrency prices, providing reliable decision-making basis for investors and regulatory agencies. However, it was also found that the model's predictive performance and practical application are limited by factors such as high uncertainty in cryptocurrency security and popularity, unstable regulatory environment and intensity.

As a frontier in the field of financial technology, the research on price prediction in the cryptocurrency market is of great significance for risk management and market stability. Although there are challenges in current GNN based prediction models, with technological advancements and global market synergy, future explorations in optimizing

model architecture, integrating multi-source data (such as social media sentiment and on chain transaction details), and enhancing model interpretability are expected to further improve the practicality and reliability of the models, and promote research and practice in the cryptocurrency market to new heights.

References

- [1] Li C, Zhu X, Li J, et al. Cryptocurrency Transaction Anomaly Detection Based on Chebyshev Graph Neural Network [C]//Blockchain and Web3 Technology Innovation and Application Exchange Conference. Springer, Singapore, 2025.
- [2] Chen Z, Liu S Z, Huang J, et al. Ethereum Phishing Scam Detection Based on Data Augmentation Method and Hybrid Graph Neural Network Model [J]. *Sensors*, 2024, 24(12):17.
- [3] Kuo Chuen D L, Guo L, Wang Y. Cryptocurrency: A New Investment Opportunity? [J]. *Social Science Electronic Publishing*, 2017.
- [4] Herbert J, Litchfield A. A Novel Method for Decentralised Peer-to-Peer Software License Validation Using Cryptocurrency Blockchain Technology [J]. 2015.
- [5] Kang J, Buu S J. Graph Anomaly Detection With Disentangled Prototypical Autoencoder for Phishing Scam Detection in Cryptocurrency Transactions [J]. *IEEE Access*, 2024, 12(000):14.
- [6] Fleischer J, Von Laszewski G, Theran C ,et al. Time Series Analysis of Blockchain-Based Cryptocurrency Price Changes [J]. 2022.
- [7] Miraz M H, Ali M. Applications of Blockchain Technology beyond Cryptocurrency [J]. *Annals of Emerging Technologies in Computing*, 2018, 2(1):1-6.
- [8] Mukhopadhyay U, Skjellum A, Hambolu O, et al. A brief survey of Cryptocurrency systems [J]. *IEEE*, 2016.8
- [9] Salman, M. K., & Ibrahim, A. A. (2020). Price prediction of different cryptocurrencies using technical trade indicators and machine learning. *IOP Conference Series Materials Science and Engineering*, 928, 032007.
- [10] Mukhopadhyay U, Skjellum A, Hambolu O, et al. A brief survey of Cryptocurrency systems [J]. *IEEE*, 2016.
- [11] Sun S F, Au M H, Liu J K, et al. RingCT 2.0: A Compact Accumulator-Based (Linkable Ring Signature) Protocol for Blockchain Cryptocurrency Monero [J]. Springer, Cham, 2017.
- [12] Colianni S G, Rosales S, Signorotti M. Algorithmic Trading of Cryptocurrency Based on Twitter Sentiment Analysis [J]. 2015.
- [13] Motsi-Omoijiade I D. Financial Intermediation in Cryptocurrency Markets – Regulation, Gaps and Bridges – ScienceDirect [J]. *Handbook of Blockchain, Digital Finance, and Inclusion*, Volume 1, 2018:207-223.
- [14] Conrad, Christian, Custovic, et al. Long- and Short-Term Cryptocurrency Volatility Components: A GARCH-MIDAS Analysis [J]. *Journal of Risk and Financial Management*, 2018.
- [15] Gladden M E. Cryptocurrency with a Conscience: Using Artificial Intelligence to Develop Money that Advances Human Ethical Values [J]. *Annales. Ethics in Economic Life*, 2015, 18.
- [16] Ittay, Eyal. Blockchain Technology: Transforming Libertarian Cryptocurrency Dreams to Finance and Banking Realities [J]. *Computer*, 2017, 50(9):38-49.
- [17] Phillips R C, Gorse D. Predicting cryptocurrency price bubbles using social media data and epidemic modelling [J]. *IEEE*, 2018.