RESEARCH PAPER

Artificial Intelligence in Bitcoin and Cryptocurrencies: Challenges, Opportunities, and Future Trends

Divya S R[1*] , Bharathi M G[2] , Vinutha V[3]

[1*] Selection Grade-Assistant professor, computer science, Vijaya college, R V Road, Basavanagudi,Bengaluru-560004,emailId:srdivya7306@gmail.com
[2]Selection Grade-Assistant professor, computer science,Vijaya college, R V Road, Basavanagudi, Bengaluru-560004,emailId:bharathimg@gmail.com
[3]Associate Professor, Computer Science , Vijaya college,R V Road Basavanagudi,Bengaluru-560004, email Id:vinuthavinash@gmail.com

***Corresponding Author:** Divya S R
[*] Selection Grade-Assistant professor, computer science, Vijaya college, R V Road,Basavanagudi,Bengaluru-560004,emailId:srdivya7306@gmail.com

Abstract
Cryptocurrencies have transformed the modern financial system by introducing decentralized digital payment methods that operate without the need for traditional banking institutions. Bitcoin, introduced in 2009 by Satoshi Nakamoto, was the first successful cryptocurrency and remains the most dominant digital currency in the market. Built on blockchain technology, Bitcoin enables secure peer-to-peer transactions through cryptographic techniques and distributed ledger systems. As the popularity of cryptocurrencies has grown, large volumes of transaction data, market trends, and online user activity have created opportunities for advanced data analysis. Artificial Intelligence (AI) and Machine Learning (ML) techniques are increasingly being applied to cryptocurrency-related challenges such as price prediction, trend analysis, fraud detection, volatility forecasting, portfolio management, and mining optimization. At the same time, issues such as privacy, security, scalability, and cyber threats continue to affect the cryptocurrency ecosystem. This paper explores the relationship between Bitcoin, blockchain technology, and artificial intelligence, while examining how AI-based approaches can improve the efficiency, reliability, and security of cryptocurrency systems. It also discusses important concepts such as blocks, blockchain structure, proof of work, and the Bitcoin mining process.

Index Terms— Bitcoin, Blockchain Technology, Cryptocurrency, Artificial Intelligence, Machine Learning, Data Mining, SHA-256, Proof of Work, Price Forecasting, Fraud Detection, Volatility Analysis, Privacy, Cybersecurity.
How to cite this article: Divya SR, Bharathi MG, Vinutha V. Artificial Intelligence in Bitcoin and Cryptocurrencies: Challenges, Opportunities, and Future Trends. Int J Drug Deliv Technol. 2026;16(48s): 1212-1220. DOI: 10.25258/ijddt.16.48s.115

I. INTRODUCTION

This study examines the application of Artificial Intelligence (AI) and Machine Learning (ML) techniques in the field of cryptocurrency. Cryptocurrency analysis has become an emerging area of research and has gained significant attention during the last decade. Bitcoin was the first decentralized cryptocurrency to use cryptographic methods for hashing and signing transactions. In 2009, an unknown person under the pseudonym Satoshi Nakamoto introduced Bitcoin as a decentralized, distributed, and peer-to-peer virtual currency [1]. It can be considered a digital form of money that exists only in electronic form. Without the support of centralized institutions such as banks, Bitcoins can be transferred directly between users through the internet.

With millions of transactions taking place through various exchange platforms, blockchain networks generate a massive volume of data every day. In addition, social media posts, news articles, and online discussions related to Bitcoin and other cryptocurrencies continue to grow rapidly. Bitcoin holders can use their assets anytime and anywhere while maintaining complete control over their funds. By removing intermediaries, the system also reduces unnecessary transaction costs. Bitcoin is based on blockchain technology, where connected blocks together form a blockchain.

*Author for Correspondence:srdivya7306@gmail.com

There is a clear need for automated systems to process and analyze this large amount of information efficiently. Through pattern recognition and data analysis, AI algorithms can learn from this data and make trading and mining activities more secure and effective. Considering the privacy and security risks associated with cryptocurrencies, AI can help detect money laundering activities, fraudulent transactions, and suspicious trading behavior. In addition to machine learning methods such as supervised, unsupervised, semi-supervised, and reinforcement learning, AI also includes knowledge-based and evolutionary approaches.

A blockchain is a sequence of blocks that stores transaction details along with the hash of the current block and the previous block. Bitcoin is generated through a process known as mining, since there is no centralized authority controlling its supply. Individuals known as miners are responsible for securing the Bitcoin network. Bitcoin can be used to purchase goods and services, and it can also be bought, sold, or exchanged for traditional currencies.

Big Data and cryptocurrencies are generally examined from two major perspectives: prediction and analysis, and security and privacy enhancement. Several previous studies have discussed blockchain technology and its applications in areas such as robotics and artificial intelligence [3], [4], and [5]. However, the use of AI techniques specifically to address challenges in cryptocurrencies has not been sufficiently explored in earlier surveys.

I. RELATED TOPICS

A. Blocks and Blockchain

These days, Bitcoin is becoming more and more popular as a substitute for fiat money on a variety of commercial platforms. A number of nations, including the United States, Japan, and Canada, began to accept Bitcoin as a form of payment [14]. Bitcoin has also become a popular alternative money for many New York establishments. In the banking system, each Bitcoin user's address serves as their account number. Similar to how we transfer a certain amount to another account using our account number, we also use Transferring Bitcoin from one individual to another requires a Bitcoin address.

A bank that validates the transaction is not the foundation of Bitcoin. To validate the transaction, miners are instead working through challenging mathematical puzzles.

This paper is based on the following exploratory questions:

• Which issues in the field of cryptocurrency have been addressed with AI techniques?

• Which artificial intelligence (AI) methods have been researched in the literature and applied to the cryptocurrency space, and what datasets are utilized there?

• What are potential areas for improvement and research gaps that warrant more investigation?

Research issues pertaining to the cryptocurrency realm are illustrated, and research on artificial intelligence and machine learning that addresses these issues is reviewed. Unquestionably, the most brilliant invention of the twenty-first century is blockchain. The original purpose of blockchain, as defined by a group of researchers in 1991, was to timestamp digital records, making it impossible to backdate or alter them. Blockchain technology was later used by Bitcoin to create the digital currency, and its potential is currently being investigated in other domains as well. With Bitcoin's rise, it is therefore seen as a groundbreaking technology that has the power to transform the world.

Bitcoin, the cryptocurrency with the largest market capitalization, has been in use for over ten years. There are currently about 18 million Bitcoins (BTCs) being bought and exchanged, and the cryptocurrency has shown remarkable success as a financial instrument

since then. However, from an economic standpoint, Bitcoin is not like other traditional assets [6].

Technically speaking, Bitcoin relies on a peer-to-peer, decentralized network that seeks to displace the centralized financial system. A distributed ledger records every transaction that occurs in a blockchain structure within this decentralized network. Every node in the network synchronizes with this blockchain to confirm the transactions.

Item	Description
Block Size	The size of the block in bytes
Block Header	Block Header with several fields in it
Counter	The total number of transaction
Transactions	Transactions in the block

Structure of a block

With Bitcoin becoming more and more well-known on a technological and financial level, it is therefore seen as a revolutionary technology that has the power to alter the course of history. A blockchain is a network of computers, or nodes, that share a common transaction history that is verified by each additional computer wishing to participate in the transaction. Anyone can access this distributed ledger at any time. It is a block chain that is backlinked. The Bitcoin network is not dependent on a centralized third party because it is a decentralized system. The Genesis block is the first block produced in the Bitcoin system. The Genesis block has no height at first, but as other blocks are stacked on top of it, the block's height increases.

The elliptic curve digital signature technique (ECDSA) is used by Bitcoin to sign transactions between the Bitcoin addresses of the sender and the recipient. Bitcoin addresses are 26–35 alphanumeric characters that are created by hashing the sender's or recipient's public keys. Bitcoin transactions are pseudo-anonymous, however using these addresses gave the impression that they were anonymous. The proof-of-work consensus method employed by Bitcoin also makes use of SHA-256 hashing.

The data that is saved on the block includes the total number of transactions, the block's size in bytes, and its header, which contains multiple fields. One crucial piece of block structure metadata is the block header. The block identification that is unique is the hash of the block header. Figure 3 below illustrates a block's structure.

The chain of interconnected blocks is known as the blockchain distributed ledger to prevent any efforts at manipulation. This is accomplished by resolving a computationally demanding cryptographic problem that is simple to verify but challenging to solve. In order to produce a block hash with a specific nonce, the nodes compete with one another.

The block reward was 6.25 Bitcoin. We refer to this process as "mining new Bitcoins." When Bitcoin first started, mining was done with a personal computer with a powerful CPU, and the PoW problem was comparatively simple. . Higher hash rates are required to solve the crypto-puzzle as its complexity rises. . Any individual block in a blockchain may be traced back to the genesis block since it is connected to the prior block. Because altering one block causes an error on the one before it, and so on, it is practically difficult to tamper with the blocks in a blockchain.

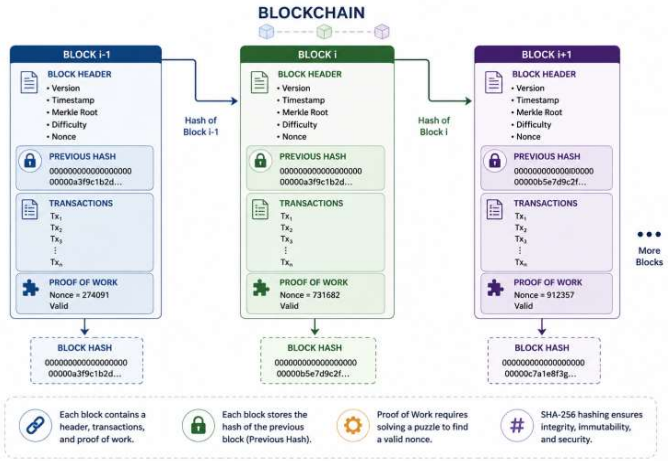
. Graphics-using computers with more processing power The majority of mining pools today employ application-specific integrated circuits (ASICs), which are specialized hardware circuits made especially for Bitcoin mining, and have extremely high processing power.

Compared to Bitcoin, there are other cryptocurrencies (altcoins) that provide faster transactions, more privacy, or other benefits. The first altcoin to be developed in an effort to enhance certain aspects, such as decentralization, security, privacy, and DNS speed, One However, Bitcoin dominates the market with more than 70% of the market share.

B. Mining

People known as miners are responsible for protecting the Bitcoin network. A miner can be any machine connected to the Bitcoin network. Over time, users have mined Bitcoin blocks using a variety of gear types. Commonly used hardware for Bitcoin mining includes CPU, GPU, FPGA, and ASIC mining. Low profits, excessive heat, and high electricity costs are among problems that hardware miners must contend with. Another answer to these issues is cloud mining, which does not have to contend with excessive heat or expensive electricity. There aren't many more restrictions, though. The miner broadcasts on the network after solving the puzzle using its computing power.

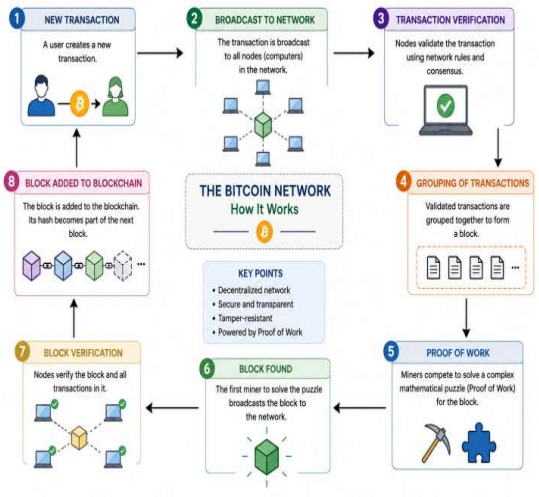
Cryptocurrencies are more resistant to governmental regulation and meddling thanks to decentralization. However, as a drawback of the market's immature laws, cryptocurrencies have been utilized on the dark web for illicit activities including as money laundering, the sale of weapons and drugs, and other crimes. Recently, several nations have begun imposing anti-money laundering (AML) and know-your-customer (KYC) requirements on exchanges while they perform research to have their government-regulated cryptocurrencies and await regulatory approval. Similarly, Facebook Libra Coin, which was supposed to begin in 2020, is awaiting the required regulatory approval. The "independent" association that oversees the Libra coin was created to address the issues of volatility and scalability that plague other cryptocurrencies.



The process of adding transaction records to the blockchain, or public ledger of previous transactions, is known as bitcoin mining [6]. Only when the sender signs a transaction is it deemed legitimate. Miners are responsible for mining, which involves constantly monitoring Bitcoin transactions and attempting to validate them. The difficulty actually becomes more difficult as more miners are added to the network; on average, a new transaction block is added to the network's blockchain every ten minutes. Proof of work is a prerequisite for a block to be deemed legitimate. A reward is given to the miner who mines the block. A reward is given to the miner who mines the block. Miners receive both the new Bitcoins as compensation and the transaction fee from each transaction that is part of the block. This encourages miners to keep competing in the quest to discover a legitimate block. Figure 6 depicts the general operation of the Bitcoin blockchain.

The issue of assessing the massive volume of trades and transactions occurring for various cryptocurrencies across various exchanges and blockchains is brought on by the notably expanding cryptocurrency market. For issues involving this vast volume of data that humans are unable to effectively examine, artificial intelligence (AI) is a strong contender. According to the conventional definition of artificial intelligence, methods and models used in AI activities can be divided into machine learning, evolutionary, knowledge, and other methods that allow machines to think and behave in a human-like and logical manner [1]. The following are the steps to run the network [1]:

• Every node receives a broadcast of new transactions. Check to see if the transactions are legitimate.



• New transactions are bundled into blocks by each node.

• Every node searches for a challenging proof-of-work for its block.

• A node broadcasts the block to every other node upon discovering a proof-of-work.

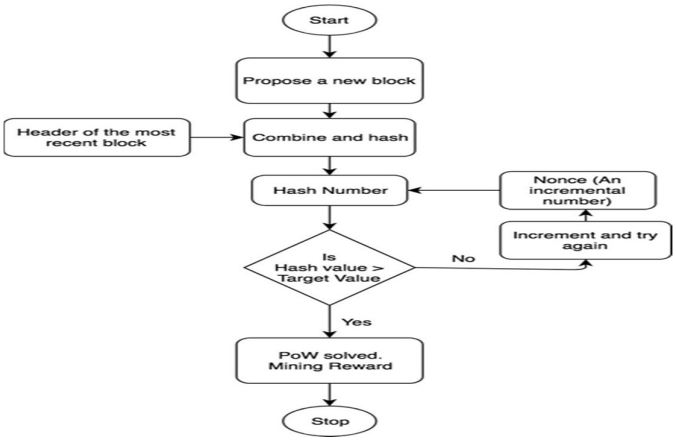
• Only after every transaction in the block is legitimate and hasn't been used up will nodes accept it.

• By utilizing the hash of the approved block as the previous hash when constructing the subsequent block

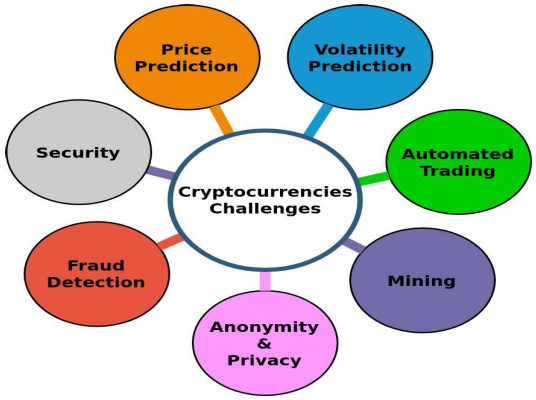
in the chain, nodes indicate that they accept the block.
In order to make trading decisions and generate large profits, automated traders can examine and learn from the market prices and indicators of cryptocurrencies. their proprietors. AI can be used by regulatory bodies to learn from data regarding prospective hazards and potential financial scams. AI methods can be used by miners to boost their earnings and reduce electricity use for environmental reasons. These methods can be used by security experts to examine and evaluate the degree of privacy and security offered by cryptocurrencies and identify potential risks.
C. Proof of Work (PoW)
The Proof of Work is a challenging mathematical cryptography problem. A value known as a nonce is searched for; when hashed using SHA-256, the resultant hash starts with the number of zeros. "Numeral only used once" is what a nonce is short for. The number of zeros in the correct hash determines how much effort is needed on average. This demonstrates that there is a significant computational cost associated with the verification process in the Proof of Work. Miners' processing power is essential to the computational process. Instead than mining individual transactions, the miners gather a number of transactions from a block and then mine that block by computing the block's hash using a different nonce.

Proof of Work Flowchart

II. CRYPTOCURRENCIES AND ARTIFICIAL INTELLIGENCE RESEARCH



The difficulties faced by fiat currencies and other financial market assets are comparable to those faced by cryptocurrencies. Business Insider Report2 from June 2019 states that AI approaches are applied in banking in three areas: credit underwriting, risk assessment, conversational banking, and anti-fraud detection. Furthermore, software solutions that use AI in the financial industry include voice assistants and financial chatbots that simulate real staff, strengthen client connections, and offer tailored insights and recommendations. Furthermore, AI is often employed in intelligent trading systems to predict currency prices and the stock market. Based on many indicators that fluctuate over time, this aids in determining when to purchase, hold, or sell a stock. Additionally, anti-fraud detection operations utilize
The miner keeps doing this until the hash that is produced is equal to or less than a specified goal value. Every miner shares the objective, which is a 256-bit value. The SHA-256 hash algorithm is used for Bitcoin hashing [3]. Finding a hash value that is smaller than or equal to the nonce is the final solution, therefore unless the cryptographic



After the hash function determines the necessary hash value, we must test several nonces and confirm it. Miners can alter a block's hash value to satisfy hash criteria by manipulating the nonce counter, which is utilized in the block header. To produce a valid hash, the nonce value will begin at 0 and increase steadily. Every two weeks, or every 2016 blocks, the target value is adjusted.Below is a display of the mining algorithm[17] that was employed during the mining process.

We may summarize the categories for cryptocurrency issues in a taxonomy depicted in Figure 3 based on the reviewed articles in this field. The trading process has a number of difficulties, including forecasting prices and trends, predicting volatility, building a portfolio, detecting fraud, and more In order to make lucrative trading decisions, these problems entail applying machine learning techniques to learn from previous price data, other market indicators, and social media interests. Furthermore, sentiment analysis and processing of news, social media posts (such as those on Twitter, Facebook, If a trading bot is designed to be conversational in order to facilitate trade, NLP may also be helpful. Moreover, NLP is a core component in the design of chatbots replying to queries and questions about cryptocurrencies.

The miner instantly broadcasts the block to the network with the accurate hash value for the specified block after determining the precise hash value.nonce. It also adds the block to its private blockchain in the process. The broadcasted block is received by the remaining miner, who promptly confirms its legitimacy by contrasting the hash value in the received block with the desired value. A block is added to the blockchain when it is deemed legitimate by the majority of miners. Bitcoin will be awarded to the miner who successfully completes the first Proof of Work and adds the block to the network. The quantity of Bitcoins mined determines the prize. Because there are only so many Bitcoins, the incentives decrease by half every 210,000 blocks that are mined, or roughly every four years. 12.5 Bitcoins are awarded to the winning miners.

The security of the cryptocurrency peer-to-peer network, user wallets, and exchange services, as well as the anonymity and privacy of cryptocurrency transactions, are additional concerns. Cryptocurrencies, and Bitcoin in particular, suffer from transaction delays since it takes time for transactions to be approved and verified across the several chains. We will categorize this issue as one of the mining problems since the transaction confirmation delay is dependent on numerous elements in the mining process. The scale of the blockchain and its high degree of replication are also seen as obstacles to cryptocurrencies, although the primary issues are with the data storage technology and protocol formulation, which are not usually addressed by AI methods. When Bitcoin mining first started, miners received 50 BCTs as payment. In addition to the compensation they earn for mining, miners also are paid a sum known as the transaction fee for each successful transaction that is added to the blockchain This amounts to twenty-one million bitcoins. Although it is a significant figure, it is probably going to be lower if we consider the demand for Bitcoin and the miners' desire to obtain this cryptocurrency.

The issues with cryptocurrencies shown in Figure 3 that AI methods can address are briefly explained in the following subsections. The research work is categorized based on the difficulty it attempts to solve. Each category's primary research publications are briefly reviewed. Many published articles have been written specifically to address the topic of price forecasting and prediction. Therefore, we could not be exhaustive in citing every piece of work that was done. Nevertheless, we chose to include papers that use diverse techniques of AI and that can contribute to answering the second question of this survey as mentioned.

IV. CONNECTED WORK

In order to add the mined block to the blockchain and receive payment, a Bitcoin miner's ultimate objective is to mine Bitcoin as quickly as possible. Dedicated gear (such as CPUs, GPUs, ASICs, and FPGAs) that use computing power, along with software programs to control these rigs, are used in the mining process. A higher hash rate and better hardware increase the likelihood of mining more quickly. A miner's compute power is measured by their hash rate. The hardware we utilize and the Bitcoin blockchain communicate with each other through Bitcoin mining software.

Domain observers and traders must perform Bitcoin/cryptocurrency analytics and forecast the price of cryptocurrencies in order to trade them. When discussing the process of estimating a price based on historical prices and other explanatory factors, the words "price prediction" and "price forecasting" are typically used interchangeably. The word "prediction" is broader because Numerous factors, sometimes referred to as indications, markers, features, or variables, can influence the price of Bitcoin. These include the interplay between supply and demand as well as investor appeal. Trends in social media, forums, search engines, statements made by leaders, and national political stability typically have an impact on these issues. Previous fluctuations in the price of cryptocurrencies or the rise or fall of trades can be utilized to identify potential trends and forecast future events. The prices of other cryptocurrencies, blockchain data, the price of gold, silver, and oil, stock market variables like the S&P 500 index (Standard and Poor 500 index, which tracks the performance of the stocks of 500 large companies on U.S. stock exchanges), and other financial technical factors are additional factors that could impact the price of cryptocurrencies.

The program is compatible with GNU/Linux, Mac, and Windows. We can download and install a large portion of this software for free and as open source. These mining programs are working on multiple projects. The software must either connect to the pool or a blockchain, depending on the user. It then selects an algorithm based on the mining program being utilized. Some miners, like

NiceHash, may dynamically swap between different algorithms, while others only use one specific algorithm. In addition to mining software, wallet and trade applications are also required. The trading program is used to view the current Bitcoin price.

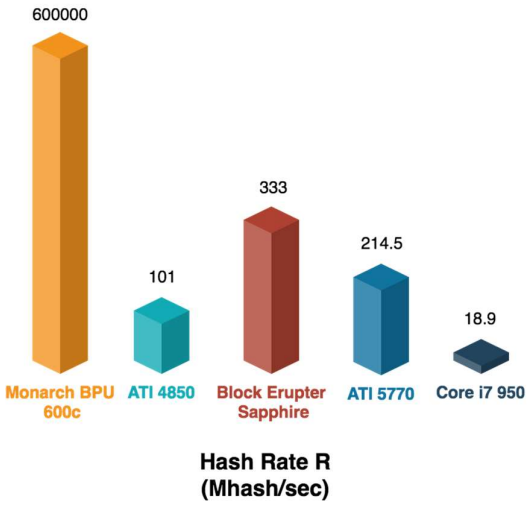
The gathering of time-series data for various variables of interest is the first step in the fundamental process of the majority of the work done in this field. Following data analysis, conclusions are drawn about the correlations between various factors and the price of cryptocurrencies. A model that can be utilized for prediction is learned from data using supervised machine learning. Price prediction is a time-series prediction challenge since it uses the history of several variables. The closing price can be predicted using a set of indicators by modeling it as a regression problem. By encoding the cryptocurrency price time series output, it may also be represented as a classification issue to determine whether the price of a coin will increase, decrease, or remain unchanged.

We must be cost-effective and hardware-efficient. Power and hash rate are the two main terms employed in these comparisons. Power, expressed in energy/time units (a watt, for instance, is joules per second), is the first derivative of energy with respect to time. The number of computations (hashes) a machine can complete in a given amount of time is known as its hash rate. Megahashes per second (Mhash/s) is the pertinent metric. Greater hash rate provided The cost and power consumption increase with the hardware. A comparison of hardware's power consumption A higher price does not always translate into a better outcome. We must observe a number of factors. We can determine that the ATI 5770 has a good hash rate in terms of cost and power consumption from the table below. However, the Monarch BPU 600 C has the highest hash rate, but it also uses more power and costs more. We must carefully consider if this investment is worthwhile in order to generate Bitcoin without suffering a loss.

We have categorized some of the most recent research in this field based on the type of model or models that are used, such as probabilistic, statistical, neural network, or tree-based models (based on decision trees). Several studies that examined various model types will be included in a different subsection. 1) Making use of models based on statistics Numerous models and statistical methods have been applied to the analysis and forecast of Bitcoin prices.

V. FINAL COMMENT

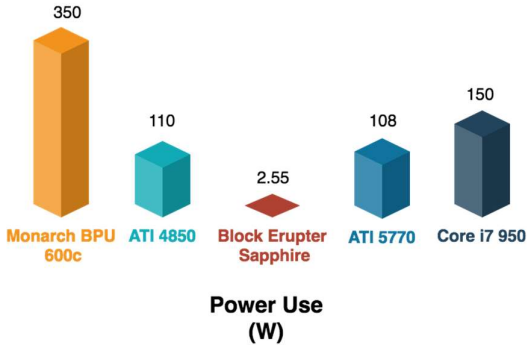
Bitcoin has already shown itself to be a well-liked digital currency. It makes use of the blockchain concept, which is said to be this century's greatest invention. As of August 19, 2018, there were more than 1600 cryptocurrencies accessible online, and the number is still rising [13]. Bitcoin is the biggest blockchain network by market capitalism, with Ethereum, Ripple, and Bitcoin Cash following [13]. Given that Bitcoin is legal in many nations, its market is anticipated to expand quickly. Since there is competition in the bitcoin mining industry, the resources used match the potential for profit. As time goes on, mining becomes more difficult, and there are less Bitcoins available for mining.



Given that Bitcoin is legal in many nations, its market is anticipated to expand quickly. Since there is competition in the bitcoin mining industry, the resources used match the potential for profit. As time goes on, mining becomes more difficult, and there are less Bitcoins available for mining. Miners can increase their chances of mining Bitcoin more quickly by using stronger hardware and innovative algorithms. A vector error-correction model (VECM) was employed in [11] to capture long-term associations between the co-integrated time series, while the ordinary least squares (OLS) criterion was used to describe the short-term influence of independent variables on the price of Bit-coins. In [15], the parameters of autoregressive distributed lag models (ARDL) were estimated using OLS based on features that describe how news-reported political incidents and statements impact price, oil and gold prices, volatility variables, Google search volume, and positive and

negative shocks. In [18] and [19], logistic regression (LR) and autoregressive integrated moving average (ARIMA) were evaluated for predicting the price of bitcoin. In [19], the stochastic properties were examined using fractionally integrated ARMA (ARFIMA) and OLS regression.

Hardware power use comparison



Deep learning was also used in [28] to predict the value of Ethereum and Bitcoin in Australian dollars (AUD). A comparison study of many deep learning models, such as deep neural network (DNN), long-short term memory (LSTM), and artificial neural network (ANN), was carried out in [20] to forecast the price of Bitcoin. LSTM-based prediction models were marginally better than other methods for regression of the Bitcoin price, but DNN-based models were better at classifying price changes, whether up or down. They also showed that categorization models performed better than regression models for trading profitability.

They used the model to predict fluctuations in prices and number of transactions at different lags In order to account for the extreme volatility of the price of Bitcoin, a Bayesian neural network (BNN) was employed in [26] to regularize the weights of input variables to a neural network. International fiat currency exchange rates, blockchain variables, and macroeconomic data were among the input variables. In terms of RMSE and MAPE, BNN was found to perform better than support vector regression (SVR).

VI. CONCLUSION

In conclusion, this analysis arranges and sorts the enormous volume of varied research that uses AI methods in the cryptocurrency space. Six classes were created from the state-of-the-art research efforts. A comparison of several research projects based on the methodologies and datasets employed was given for every class. In this extremely active subject, we highlighted potential research gaps and open directions that need further development. We did our best to cite recent articles that investigated a wide range of diverse AI strategies to handle distinct difficulties, even though we haven't acknowledged every research publication in the field. Researchers interested in applying AI and machine learning methods to the cryptocurrency space would find this survey to be very beneficial. Bitcoin has already shown itself to be a well-liked digital currency. It makes use of the blockchain concept, which is said to be this century's greatest invention. there were more than 1600 cryptocurrencies accessible online, and the number is still rising . Bitcoin is the biggest blockchain network by market capitalism, with Ethereum, Ripple, and Bitcoin Cash following . Given that Bitcoin is legal in many nations, its market is anticipated to expand quickly. Since there is competition in the bitcoin mining industry, the resources used match the potential for profit. As time goes on, mining becomes more difficult, and there are less Bitcoins available for mining By providing condensed summaries of some of the research conducted in this field and the methods employed, as well as a list of some of the datasets they used to solve the various cryptocurrency difficulties, it provides them with a brief but comprehensive understanding of this diverse field.

REFERENCES

[1] Taoufik Rachad and Ali Idri, " Intelligent Mobile Applications: A Systematic Mapping Study," Mobile Information Systems, vol. 2020, no. 6715363, 2020. https://doi.org/10.1155/2020/6715363 .

[2] K. R. Ramkumar and C.S. Ravichandran, " A Novel node failure Management for Mobile Ad hoc networks using ant agents," International Journal of Engineering and Technology, vol. 6, no. 1,pp. 306-314, 2014.

[3] Zahra, Husam Abu, and Samer Zein. "A Systematic Comparison Between Flutter and React Native from Automation Testing Perspective." 2022 International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT). IEEE, 2022.

[4] Biørn-Hansen, Andreas, et al. "An empirical investigation of performance overhead in cross-platform mobile development frameworks," Empirical Software Engineering vol. 25, no. 4,pp. 2997-3040, 2020.

[5] N. Tuli, and A. Mantri, "Evaluating usability of mobile-based augmented reality learning environments for early childhood," International Journal of Human–Computer Interaction, vol. 37, no. 9, pp. 815-827, 2021.

[6] Henning Heitkötter, Sebastian Hanschke and

Tim A. Majchrzak, “Comparing cross-platform development approaches for mobile applications,” Web Information Systems and Technologies. pp. 120–138, LNBIP, Springer, 2013.

[7] Andre Charland and Brian LeRoux, “Mobile application development: Web vs. Native,” In Communications of the ACM, Vol 54, pp. 49–53, Issue 5, May 2011.

[8] Paulo R. M. de Andrade, Adriano B. Albuquerque. “CROSS PLATFORM APP A COMPARATIVE STUDY”. International Journal of Computer Science & Information Technology (IJCSIT) Vol 7, No 1, February 2015

[9] JQuery Mobile . Last access : December 2015. https://jquerymobile.com/

[10] Sensha Touch . Last access: December 2015.https://www.sencha.com/products/touch/

[11] Jqt. Last access : December 2015. http://jqtjs.com

[12] HTML5. Last access : December 2015. http://www.w3.org/TR/html5

[13] Xing Jin, Tongbo Luo, Derek G. Tsui and Wenliang Du. “Code Injection Attacks on HTML5-based Mobile Apps”.

[14] Ionic Framework. Last access: December 2015. http://ionicframework.com

[15] Apache Cordova. Last access: December 2015. https://cordova.apache.org/

[16] PhoneGap. Last access: December 2015. http://phonegap.com/.

[17] Angularjs. Last access: December 2015. https://angularjs.org/

[18] SASS. Last access: December 2015. http://sass-lang.com/

[19] MoSync. Last access: December 2015. http://www.mosync.com/

[20] Appcelerator. Last access: December 2015. http://www.appcelerator.com/

[21] Smartface. Last access: December 2015.https://www.smartface.io/

[22] Xamarin. Last access: December 2015. https://xamarin.com/

[23] Codename One. Last access: December 2015. https://www.codenameone.com/

[24] L’uboš staráˇcek and Valentino vrani´c. “MDA Based Multiplatform Mobile Application Modeling with Platform Compliant User Interfaces”.

[25] Florence T. Balagtas-Fernandez. “Model-Driven Development of Mobile Applications,” IEEE/ACM International Conference on Automated Software Engineering. pp. 509-512 ,2008 [IEEE Computer Society Washington, DC, USA] .

[26] MD2. Last access: December 2015. http://wwu-pi.github.io/md2-web

[27] Henning Heitkötter, Tim A. Majchrzak, Herbert Kuchen. “Cross-Platform Model-Driven Development of Mobile Applications with MD2”. SAC '13 Proceedings of the 28th Annual ACM Symposium on Applied Computing, pp. 526-533, Coimbra, Portugal March 18 - 22, 2013.

[28] Rahul Murmuria, Jeffrey Medsger, Angelos Stavrou. “Mobile Application and Device Power Usage Measurements” .

[29] Cassandra Beyer “Mobile Security: A Literature Review”.

[30] Soumya Kanti Datta, Christian Bonnet and Navid Nikaein, “Android power management: Current and future trends,” int the First IEEE Workshop on Enabling Technologies for Smartphone and Internet of Things (ETSIoT), pp.48,53, 18 June 2012.

[31] Jaymin Lee, Hyunwoo Joe and Hyungshin Kim, “Smart phone power model generation using use pattern analysis,” 2012 IEEE International Conference on Consumer Electronics (ICCE), pp. 412,413, 13-16 Jan. 2012.

[32] Denim Group, “Secure mobile application development reference”, 2010- 2011.

[33] Satoshi Nakamoto *” Bitcoin: A Peer-to-Peer Electronic Cash System. ”*. March 2009

[34] Wikipedia *”https:// en.wikipedia.org/ wiki/ History_of _ bitcoin”*. Accessed, 25 Jul. 2018

[35] D.E. III and T.Hansen, *”US Secure Hash Algorithms(SHA and SHA-based HMAC and HKDF)”,* Available: ”http://www.ietf.org/rfc/rfc6234.txt”, 2011

[36] K. Kaskaloglu *”Near zero bitcoin transaction fees cannot last forever”*. 2014, pp. 91-99

[37] Coinmarketcap*” https://coinmarketcap.com/currencies/bitcoin/”*. Accessed. July 22, 2018

[38] Bitcoinmining *” https://www.bitcoinmining.com/”*.Accessed. July 27, 2018

[39] Iddo Bentov, Charles Lee, and Alex Mizrahi. *” Proof of activity: Extending bitcoins proof of work via proof of stake. ”*.

[40] Usman W. Chohan. *”The double-spending problem and cryptocurrencies”*. December 19, 2017

[41] bitcoin.it. Mining hardware comparison *”https:*

[42] *// en.bitcoin.it/ wiki/ Mining_hardware_ comparison”*.

[43] Karl J. O’Dwyer and David Malone *” Bitcoin Mining and its Energy Footprint ”*. CIICT 2014, Limerick, June 26-27

[44] Mauro Conti, Sandeep Kumar E, Chhagan Lal, Sushmita Ruj *” A Survey on Security and Privacy Issues of Bitcoin ”*. Dec 2017

[45] Legality of bitcoin by country or territory ”https:// en.wikipedia.org/ wiki/ Legality of bitcoin by country or territory”. Accessed August 16, 2018