Systematic Erudition of Bitcoin Price Prediction using Machine Learning Techniques

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***Abstract*—Bitcoin (BTC) is an internet-based world's top-ranking cryptocurrency. Among widespread cryptocurrencies available in the market, Bitcoin is most experienced by the people due to anonymity and transparency in the system. Daily trends in the Bitcoin market has gained popularity among the spectators, investors, consumers and many more. Bitcoin price data exhibit desirable properties where some classical time series prediction methods exploit the behavior, producing poor predictions and also lack a probabilistic interpretation. This paper conducts an in-depth study on evolution of Bitcoin and also a systematic review is done on various machine learning algorithms used for predicting the prices. Comparative analysis envisions to select optimal technique to forecast prices more precisely.**

Keywords—Bitcoin, Bitcoin prediction, cryptocurrency, machine learning

I. BITCOIN PRIMER

In the modern era, Digital currencies are a trendsetter and cryptocurrency is subset of digital currency. Following are the parameters that differentiate between cryptocurrency and digital currency.

1] Pseudonimity: For digital currencies, user needs to prove their identification by showing their photo or any documents whereas in cryptocurrencies, the user is anonymous. Only the private key and public key is taken into consideration for transaction process.

2] Structure: Cryptocurrency is decentralized and is not regulated by any other authority or community. Digital currency is regulated by officials or some authorized person.

3] Legal Aspect: In most of the countries there exist some legal framework for digital currency whereas for the cryptocurrency, their official status is not defined.

4] Transparency: Cryptocurrency is transparent and is traced so anyone can see the transactions that take place in network. In digital currency, the e-wallets are chosen and money is directly transferred into the receivers account without revealing any transactions.

Examples of Digital Currency - PayPal, Paytm.

Examples of Cryptocurrency - Bitcoin, Ripple.

Bitcoin was first introduced by Satoshi Nakamoto (pseudonym for a person or a group whose identity is still unknown) in January 2009 [1]. Bitcoin was specifically designed to be a medium of exchange without any intervention of third party or any financial institution. People use bitcoin as a medium of exchange and also as an investment where user is allowed to exchange the bitcoins directly with other user in closed network. The system is completely decentralized, and all the transactions take place in peer-to-peer network.

1 bitcoin can be converted into 1 hundred million 'Satoshis'. Satoshis is named after the founder Satoshi Nakamoto. 1 Satoshi is represented as 0.00000001 bitcoin. First bitcoin client was released on 9th January, 2009. First transaction was made between Satoshi Nakamoto and Hal Finney on 12th January, 2009. On 6th February, Bitcoin exchange was established by member of the Bitcointalk. Later on many bitcoin exchanges were established. Mt. Gox. became the largest Bitcoin exchange method. Satoshi Nakamoto mined the first ever bitcoin block in 2009 which consist of 50 bitcoins. After that, Bitcoin block is mined for every 10 minutes.

Bitcoin is widely accepted by over 40 countries such as Germany, Croatia, Switzerland, Canada etc. as cryptocurrency.

II. BITCOIN NETWORK

The Bitcoin transaction takes place in a closed network. Graph mining algorithms provides descriptive statistics and analysis of Bitcoin network. It is necessary to examine all the transactions in the network. These transactions depicts the user behavior, transaction amount and other factors of the network which are necessary to forecast the prices. The parameters such as network usage and exchange rate enables us to understand which network is stronger. Small transactions also carry out highest amount of Bitcoins. Degree centrality helps to find the largest hub in the network[2].

In July 2010, first commercial Bitcoin exchange was created out of a website for trading cards from Magic: The Gathering Online and it was called Mt. Gox. The value of Bitcoin before Mt. Gox. was 0.008 USD/BTC. Mt. Gox. became the largest Bitcoin exchange method even though there were some other bitcoin exchanges available in the market. The first Bitcoin conference happened in USA in New York and in Europe in Prague. The first actual bitcoin exchange called BitcoinCentral (now Paymium), obtained a European bank license. The purpose of Bitcoin mining is to avoid double spending that creates new bitcoins in a controlled manner. On bitcoin network constantly transactions take place. Each block of bitcoin transactions must be associated by a hash value.

Transactions are carried out over the Bitcoin network continuously. The Miners, who want to participate in the network, make an attempt to a block to Blockchain. In

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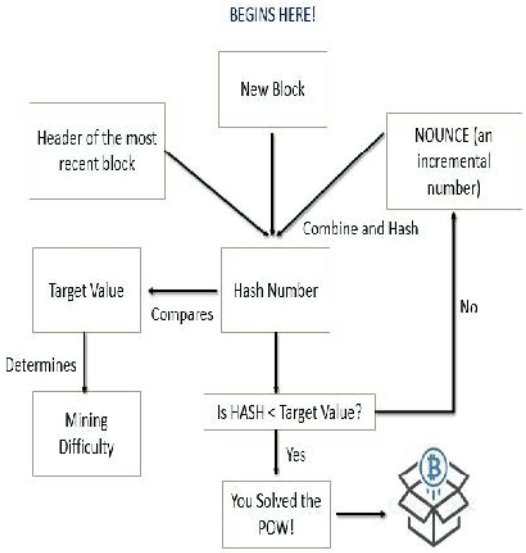

Fig. 1. Working of Bitcoin Transaction

2009, blockchain protocol was released as open source. The blockchain technology enabled bitcoin to introduce into the system the unprecedented and transformative ability to decentralize the processing of payments. Blockchain is a decentralized shared public ledger of all transactions in Bitcoin system. Bitcoin is accessible to all users and does not need any permission to participate in mining.

The blockchain ledger is not own by any other protocol or ruling authority. All the computing devices participating in the protocol can access to a shared public ledger. Record of every transaction occurring in bitcoin system is stored in shared public ledger. Cryptographic blocks are used to validate the transaction. All the transactions are tracked and recorded. Addition of blocks and verifying the stored blocked enables to maintain the integrity within the Bitcoin system. Since each block in the blockchain is associated with hash value, user can backtrack to retrieve the transaction details. Only valid transactions are stored in the memory and adjoined to the blockchain.

A user participates in the network during the transaction. The user also known as Miner has to maintain the Wallet for Bitcoin Transaction. In order to participate in the transaction, the user has to gather the data from transactions and append block chain. The Wallet contains public and private key. The public key is visible to all as an identity to those who wants to participate in the transaction. The sender and the receiver create network, public keys are exchanged to start the transaction. The private key is exchanged to send the specific amount to the receiver. Private key generates the digital signature for authentication of sender, receiver and transaction. If the miner successfully solves the hash values for a particular block, then the miner is added in the transaction history. The miner [3] is also rewarded if the hash value is solved earlier than the expected time. Bitcoin transaction is validated by proof-of-work [4] as shown in Fig. 1. Computers participating in the network has to solve a cryptographic puzzle with a desired answer, the transaction

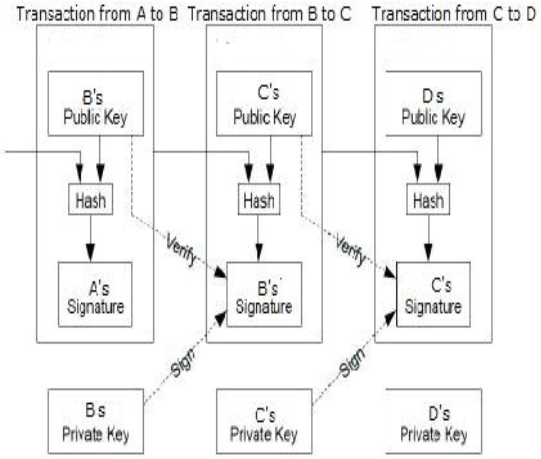

Fig. 2. Transaction with public and private key

is recorded in the Blockchain. In Fig. 2 we can see the private key is encrypted and cannot be accessed by anyone. Due to the surge in Bitcoin prices, users are progressively contributing on exorbitant specialized hardware for Bitcoin mining. To achieve balanced payouts, users pool their computation resources to direct pool mining. Currently there are 21 million Bitcoins available to the users. The Bitcoin system is capable of 7 transactions per seconds.

Due to absence of regularity in the Bitcoin market, the forecasting of the accurate prices has become a challenging task. According to the complexity, Machine learning classifiers and Deep Learning provides a good solution to forecast the Bitcoin future prices. Bitcoin is not limited to small scale industries and is growing rapidly. As the number of users cannot be specified, but according to the number of wallets and number of transactions per day there's a major growth in the number of users.

III. ESTABLISHED METHODS AND APPROACHES

As the Bitcoin prices are volatile in nature, there exist many techniques to forecast the Bitcoin prices. In this research study, we have attempted to provide an insight of various price prediction techniques along with various other factors. Each discussed technique is unique and targets special scenario. The details of each methodology is discussed as follows.

A. Auto-Regressive Integrated Moving Average Model

Implements time series data that is linear and pursues a specific known statistical distribution, for example, normal distribution. ARIMA (Auto-Regressive Integrated Moving Average) is parametric model that predicts individual time series. This model forecast time series data with uncertainty within short term period. It cannot predict more than one time series in parallel. Data exhibits consistent or stable pattern over time with least possible outliers. The output values are close to the previous stated values so deriving conclusions from the prediction is not guarantee. Prediction of accurate price is simplified by using threshold for the prediction[5]. In Bitcoin, the values are volatile [6] leading to the series of prices showing fluctuations at a faster rate. Since the values are not

stationary, the volatility increases and the accuracy is not matched[7]. The prediction values of ARIMA model failed poorly when parameters such as RMSE and accuracy is considered. The class imbalance also causes biased forecast.

B. Regression Model

Linear Regression model estimates the coefficient of values. The data such as bitcoin values are collected from the recorded data set to forecast the value. Feature extraction and selection excludes the imputed or incorrect values. This helps to improve the prediction more efficiently[8]. Fundamental Analysis observes volatile prices of economy and helps in decision making of prices in cryptocurrency. Technical Analysis studies the market data for prediction of prices. Market data collected over years is represented as training data set. Prediction is done by generating a regression model from linear and multiple regression techniques. Learned Linear model provides unsuitability to forecast the time series of Bitcoin price[9].

C. Latent Source Model

Latent Source Model (LSM) was developed by G. H. Chen for binary classification[10]. Bayesian Regression is binary classification algorithm used for predicting the varying price of Bitcoin. In Bayesian Regression, data acts as proxy for Bayesian inference. The problem of unknown labels is resolved with use of training data for prediction. The results obtained from the traditional approach is explained and drawbacks are plotted for further work. In traditional approach, the labeled data represents noise which fails in future prediction. Latent Source Model in conjunction with Bayesian Regression examines the existing patterns in system. The average price is predicted at an interval of 10 second with the help of trading strategy which allows the user to make the decision i.e. whether to buy or sell bitcoin. The algorithm gave 200% returns in less than 60 days by using trading strategy. Three positions of bitcoin are set up, where average price is predicted at time instance. According to the threshold defined if average price value less than threshold, then Bitcoin is sold else it is purchased. Thresholds are changed at regular intervals to observe the performance of the trading strategy. Using Sharpe ratio, it is observed that trading strategy performs consistently over time and yields better results during high fluctuations.

D. Binomial Generalized Linear Model

Binomial Generalized Linear Model (BGLM) analyses linear and non-linear effects on a discrete or continuous dependent variable. The aim of this model is to provide estimation of model parameters[11]. The linearization problem in Bitcoin data set can be resolved by GLM, yielding the price change prediction [12] GLM contains random component, systematic component and link function as main components.

E. Generalized Autoregressive Conditional Heteroskedasticity Model

The main feature model is to collect volatility clustering in the data. The "persistence" parameter keeps an account for the amount of volatility clustering is collected by the model. Generalized Autoregressive Conditional Heteroskedasticity Model (GARCH) estimates volatility of prices[13]. GARCH model transforms the standard OLS (Ordinary Least Squares) residuals into an endogenous process that allows its variance to vary across periods. It captures excess kurtosis (i.e. fat tail behavior) and volatility clustering. ARCH test is used for conditional heteroskedasticity to assure that there exist ARCH effects in Bitcoin price index, proposing that the autoregressive model for the conditional mean needs to be expanded to include an Autoregressive Conditional Heteroskedasticity model for the conditional variance [15]. Large changes in the squared returns tend to cluster together, and small changes tend to cluster together, which also indicates that the series exhibits conditional heteroskedasticity. It yields precise forecast of variances and covariances of returns through modeling time-varying conditional variances.

F. Support Vector Machine Model

Predictive models for classification and regression problem is a Support Vector Machine (SVM) works by creating a higher-dimensional model which assigns each new data provided to one category or another[16]. Decision is obtained from the verge that which maximizes the functional and geometric margins between classes. SVM model is best for resolving classification problems.

G. Long Short Term Memory Network Model

Long Short Term Memory Network Model (LSTM) is unique type of Recurrent Neural Network (RNN) specifically used to cease long-term dependency problem. Information is stored for longer period, this marks as their default behavior. It selects the necessary information to be store and discards the irrelevant information. The sequential characteristics in the time series data is ignored by many of the machine learning algorithms. This problem is identified in rolling window LSTM[18]. Application of any other machine learning classifiers on time series data usually overlook the sequential data. Rolling window LSTM builds model structure for time series prediction by not considering weights. LSTM takes longer time to train as compared to RNN model, the parameters and activation functions increased the computation leading to long term memory.

H. Non-linear Auto-Regressive with Exogenous Input Model

NARX model [19] is a recurrent dynamic network, with feedback connections enclosing several layers of the network. It can accept the dynamic time series data. The main feature of this model is that it can accept discrete as well as continuous values for the prediction of data. The NARX model is constructed from linear ARX model to predict the prices of bitcoin. It understands the behavior of a system, converges much faster and generalizes in a more effectively than any other neural networks. It is mostly used in forecasting the time series in order to achieve higher accuracy in prediction results.

I. MultiLayer Perceptron Model

A MultiLayer Perceptron (MLP) is a deep, artificial neural network consisting of more than one perceptron. The structure is composed of input layer to receive the

data, arbitrary number of hidden layers for the computation of received data and output layer to provide prediction or decision to input values. Backpropogation is used by MLP. MLP are often applied to supervised learning problems which provides set of data, train the model includes adjusting the parameters in order to minimize the error and provide decision with higher accuracy. It can be used for the approximation of any continuous functions. Forecasting the further prices, [22] MLP uses binary classification problem targeting the values as 1 or 0. 1 represent the Bitcoin price will increase for the next day and 0 represent the Bitcoin price will drop for the next day.

IV. OBSERVATION

Digitalization and Cryptocurrency joined together for evolution of Bitcoin system. Bitcoin system demonstrates that competition in bitcoin mining done by the miners leads to a great challenge in forecasting the future prices. The

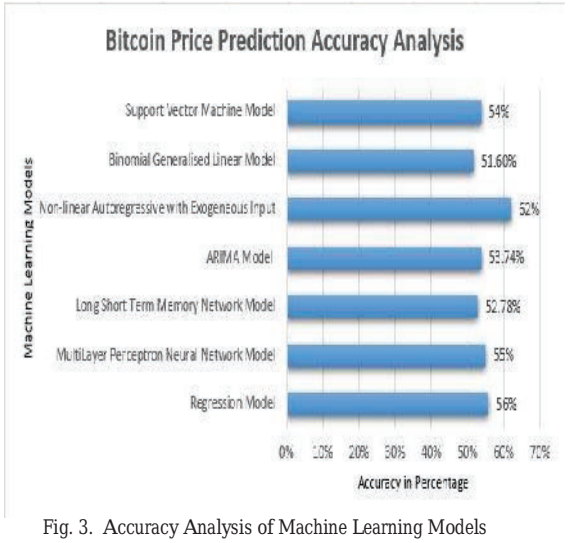

Fig. 3. Accuracy Analysis of Machine Learning Models

centrality of research lies in seeking to maximize welfare of people. Since popularity is skyrocketing, there exists some issues that makes the system vulnerable. Bitcoin allows the user to participate in the transaction without any intervention of the third party or any financial institutions. Also, there are no brokers who takes additional charges. The prices that are predicted may differ in true values due to the volatility. Users try to check the authenticity of those values and invest in Bitcoin. This leads to loss in investment.

Economic status of currency, miners, bitcoin exchanges are some of the factors where as there might be some unexplored topics that need to be investigated. The monetary needs of the society determines to forecast the future prices of Bitcoin with higher accuracy rate. Fig. 3 enables us to understand the accuracy of the existing techniques. By looking at the figure, we exhibit the model for further implementation of Bitcoin price prediction. Accuracy level obtained from the models enhance to overcome the drawbacks of the existing systems. The existing system has implemented the prediction of prices successfully but the accuracy level attained by them is less precise. The existing systems has explained the architecture and complete flow of model, denoting the limitations and a need for improvement in the system.

V. CONCLUSION

Bitcoin system is unique from any other asset on the financial market and thereby creates new possibilities. Our work can serve as an exploratory beginning for several techniques, descriptive analysis of Bitcoin prices. As the network is large, small as well as large transactions are carried out in this network resulting in volatility of prices which needs to be maintained. The results show survey of techniques that used and also the technique which suits best for the prediction. The solutions provided in many of the existing system gives 60- 70% accuracy. Although some techniques are not considered as the accuracy obtained by them is very less, the overall study is very promising and can help investors to invest accordingly. In Fig. 3. the accuracy of NARX Model is the best model in predicting the Bitcoin prices. The analysis conducted in this work can be further extended by more research on upcoming advance methods. Hence more thorough picture of forecasting prices can be obtained. The main motive of the paper is to adapt volatility of prices and forecast the prices of Bitcoin with precision.

REFERENCES

[1] Vladimir Malik, "The history and the future of Bitcoin", Bachelor Thesis, April 2016.

[2] Annika Baumann, Benjamin Fabian, Matthias Lischke, "Exploring the Bitcoin Network", International Conference on Web Information Systems and Technologies (WEBIST), Institute of Information Systems, Humboldt University Berlin, Berlin, Germany 2014.

[3] Luqin Wang, Yong Liu, "Exploring Miner Evolution in Bitcoin Network", NYU Polytechnic School of Engineering, Brooklyn, USA.

[4] Tengfei Xue, Cong Wang, Yuyu Yuan, "An Approach for Evaluating User Participation in Bitcoin", 2018 IEEE Third International Conference on Data Science in Cyberspace, School of Software Engineering, Beijing University of Posts and Telecommunications, Key Laboratory of Trustworthy Distributed Computing and Service(BUPT), Ministry of Education Beijing, China, 2018.

[5] Aaron Visschedijk, "Trading Bitcoin Using Artificial Neural Networks", Thesis, Radboud University, Netherlands, June 2018.

[6] Tian Guo, Nino Antulov-Fantulin,"An experimental study of Bitcoin fluctuation using machine learning methods", Association for Computing Machinery, Zurich, Switzerland, June 2018.

[7] Sean McNally, Jason Roche, Simon Caton, "Predicting the Price of Bitcoin Using Machine Learning", 26th Euromicro International Conference on Parallel, Distributed, and Network-Based Processing, School of Computing, National College of Ireland, Dublin, Ireland, 2018.

[8] Abhyudit Bisht,Puru Agarwal, "Analysis of Bitcoin using Linear Regression and Data Mining Techniques", International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE), Department of Computer Science and Engineering, SRM University Chennai India, vol. 6, Issue 11, November 2017.

[9] Huisu Jang, Jaewook Lee, "An Empirical Study on Modeling and Prediction of Bitcoin Prices With Bayesian Neural Networks Based on Blockchain Information", IEEE Department of Industrial Engineering, Seoul National University, Seoul, South Korea, Vol.6, 2018.

[10] Devavrat Shah, Kang Zhang, "Bayesian regression and Bitcoin", IEEE Fifty-second Annual Allerton Conference, Allerton House,

UIUC, Illinois, USA, Laboratory for Information and Decision Systems, Department of EECS, Massachusetts Institute of Technology, October 2014.

[11] Siddhi Velankar, Sakshi Valecha, Shreya Maji, "Bitcoin Price Prediction using Machine Learning", International Conference on Advanced Communications Technology(ICACT), Department of Electronics and Telecommunication, Pune Institute of Computer Technology, Pune, Maharashtra, India, February 2018.

[12] Isaac Madan, Shaurya Saluja, Aojia Zhao, "Automated Bitcoin Trading via Machine Learning Algorithms", Department of Computer Science, Stanford University, Stanford, 2015.

[13] Brian Vockathaler, "The Bitcoin Boom: An In Depth Analysis Of The Price Of Bitcoins", Thesis, University Of Ottawa, Ontario, Canada, June 2017.

[14] Amlie Charles, Olivier Darne,"Volatility estimation for Bitcoin: Replication and extension", France, February 2018.

[15] Paraskevi Katsiampa, "Volatility estimation for Bitcoin: A comparison of GARCH models", Economic Letters, vol. 158, pp. 3-6, September 2017.

[16] Alex Greaves, Benjamin Au, "Using the Bitcoin Transaction Graph to Predict the Price of Bitcoin", December 2015.

[17] Andrew Hencic, Christian Gouriroux,"Noncausal Autoregressive Model in Application to Bitcoin/USD Exchange Rates", Springer International Publishing Switzerland, Toronto, Canada, 2015.

[18] Jang Huisu, Jaewook Lee, Hyungjin Ko, Woojin Lee, "Predicting Bitcoin Prices by Using Rolling Window LSTM model", ACM, July 2018.

[19] N.I. Indera, I.M. Yassin, A. Zabidi, Z.I. Rizman, "Non-linear Autoregressive with Exogeneous Input (NARX)Bitcoin Price Prediction Model using PSO-Optimized Parameters and Moving average technical indicators", Thesis, Malaysia, September 2017.

[20] Obryan Poyser, "Exploring the determinants of Bitcoins price: an application of Bayesian Structural Time Series", Thesis, June 2017.

[21] John Mern, Spenser Anderson, John Poothokaran, "Using Bitcoin Ledger Network Data to Predict the Price of Bitcoin", Stanford University Department of Aeronautics and Astronautics.

[22] Edwin Sin, Lipo Wang, "Bitcoin Price Prediction Using Ensembles of Neural Networks", 13th International Conference on Natural Computation, Fuzzy Systems and Knowledge Discovery (ICNC-FSKD), Nanyang Technological University, Singapore, 2017.

[23] Gerald P. Dwyer, "The economics of bitcoin and similar private digital currencies", Journal of Financial Stability, vol. 17, 2015, pp. 81-91.

[24] C.V. Arulkumar et al., "Secure Communication in Unstructured P2P Networks based on Reputation Management and Self Certification", International Journal of Computer Applications, vol. 15, pp. 1-3, 2012.

[25] V. Arulkumar. "An Intelligent Technique for Uniquely Recognising Face and Finger Image Using Learning Vector Quantisation (LVQ)-based Template Key Generation," International Journal of Biomedical Engineering and Technology 26, no. 3/4 (February 2, 2018): 237-49.

[26] H. Anandakumar and K. Umamaheswari, "Supervised machine learning techniques in cognitive radio networks during cooperative spectrum handovers," Cluster Computing, vol. 20, no. 2, pp. 1505–1515, Mar. 2017.

[27] H. Anandakumar and K. Umamaheswari, "An Efficient Optimized Handover in Cognitive Radio Networks using Cooperative Spectrum Sensing," Intelligent Automation & Soft Computing, pp. 1–8, Sep. 2017.

[28] Anandakumar, "Energy Efficient Network Selection Using 802.16g Based Gsm Technology," Journal of Computer Science, vol. 10, no. 5, pp. 745–754, May 2014.