

## A Study on Machine Learning Techniques and Effect of an Optimization Algorithm on Stock Market Prediction

<sup>a</sup>Rekha KS, <sup>b</sup>Sabu MK

<sup>a</sup>Research Scholar, Department of Computer Applications Cochin University of Science and Technology, Kochi, Kerala, India

<sup>b</sup>Associate Professor, Department of Computer Applications Cochin University of Science and Technology, Kochi, Kerala, India

### Abstract

Stock markets are unpredictable and dynamic and the factors influencing the stock prices are quite complex. A review on different machine learning techniques has been done, with a focus on the recent ones. The research trends in this area is identified and an effort has been made to present this in the area of stock market prediction. We have analyzed different methods used in machine learning in stock market prediction with emphasis given to the latest methods such as recurrent neural networks. An attempt is made to show the effect of Adaptive Moment Estimation optimization algorithm in Stock Market Prediction that uses Recurrent Neural Networks with Long Short Term Memory.

**KEYWORDS** – Deep Learning, Long Short term memory, Adaptive Moment Estimation, Sequence Prediction, Stock Market Prediction

### I. INTRODUCTION

Stock market prediction has been a relevant research topic for quite some time due to the high financial stakes involved in this area. Prediction of the future value of stock is known as stock market prediction and this information can be quite crucial to the investors. Reasonably correct stock market prediction will result in high dividends. It is also useful for other stakeholders like regulators for making corrective measures. Many mathematical models were developed in the past, but the performance of these models were not satisfactory [1]. According to Fama[2] stock prices gets adjusted based on firm specific information. Since apriori information is difficult to incorporate, prediction seems to be a difficult task. In a general perspective stock market prediction can be classified into three broad categories as shown in fig. 1.

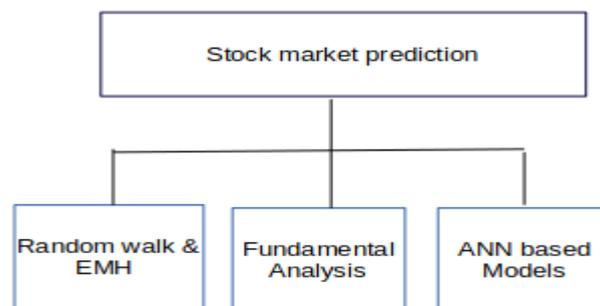


Fig 1:- Broad Classification of Methods

Most of the earlier modes for stock market analysis were based on Efficient Market Hypothesis(EMH) and Random Walk Theory [3][4]. In the Random Walk theory and EMH it is stated that based on the present and historical information it is difficult to achieve more than above average trading advantage. According to EMH stock market price is not in predictable form and not a realistic method for representing the stock market. Fundamental analysis uses real public data and help investors to buy best stocks in the market. ANN based models is the latest trend due to its high accuracy and uses present and historical stock data index to predict future prices[5][6]. The effects of ANN models have been analyzed in stock market prediction in[7]. A comparative study of the classification methods is given in Table 1.

Table 1. Comparative Study of Classification Methods

|                 | Classification Methods                |  |                    |
|-----------------|---------------------------------------|--|--------------------|
| Criteria        | Random Walk and EMH                   | Fundamental Analysis   | ANN based Models   |
| Data Used       | Price, Volume, highest, lowest prices | Growth, dividend payment, sales level, interest rates, tax rates | Set of simple data |
| Learning Method | Trading rule extraction from charts   | Extraction of simple trading rules                               | Inductive learning |
| Type of tools   | Charts                                | Trading rules  | Neural Networks    |
| Implementation  | Daily Prediction                      | Long-term Prediction   | Daily Prediction   |

Many researchers have proposed different models and algorithms for making market predictions. Predicting the stock market is a sequence prediction task and it has attracted much attention in the academia. Stock market prediction can be considered as a time series prediction and accurately predicting time series financial data is a difficult task.

Machine learning is a branch of Artificial Intelligence in which systems learn automatically from previous experience. Machine learning has different applications in various fields including computer networks, telecommunications, bioinformatics, forecasting, information retrieval and linguistics. With the emergence of data analysis using machine learning techniques there has been a paradigm shift in stock market prediction. Different techniques in machine learning can be used efficiently to predict the stock market data. Algorithms that use machine learning allows computers to use the data that is available to predict the future trends and outcomes. In order to minimize or maximize an objective function or error function we use the optimization algorithm. In this paper an attempt is made to analyze stock market prediction using Adaptive Moment Estimation(ADAM) optimization algorithm[15].

The rest of the paper is organized as follows. Section II gives an overview of the Literature Review. Methodology is presented in section III. Section IV gives the

Results and Discussions. Conclusions and Future Scope are given in Section V.

## II. LITERATURE REVIEW

One of the application of sequence prediction is in forecasting problems. There are different sequence prediction problems[21][22] such as product recommendation, weather forecasting, stock market prediction etc. One typical application where sequence prediction can be applied is in stock market prediction. Different machine learning techniques can be used in short term and long term stock price prediction. Machine learning techniques can be broadly classified into supervised and unsupervised learning. Supervised learning can be divided into classification and regression. Support Vector Machines(SVM) come under classification whereas linear regression and Support Vector Regression(SVR) comes under regression methods. In unsupervised learning we have Hidden Markov Models(HMM) and Neural Networks(NN). The latest developments in neural networks such as deep learning includes Convolution Neural Networks(CNN) and Recurrent Neural Networks(RNN)[20]. In short, machine learning techniques include supervised and unsupervised learning which can be subdivided into regression, support vector machines, Hidden Markov Models, convolution neural networks, recurrent neural networks which include long short term memory etc.

Stock market prediction using machine learning can be classified as shown in the following fig. 2.

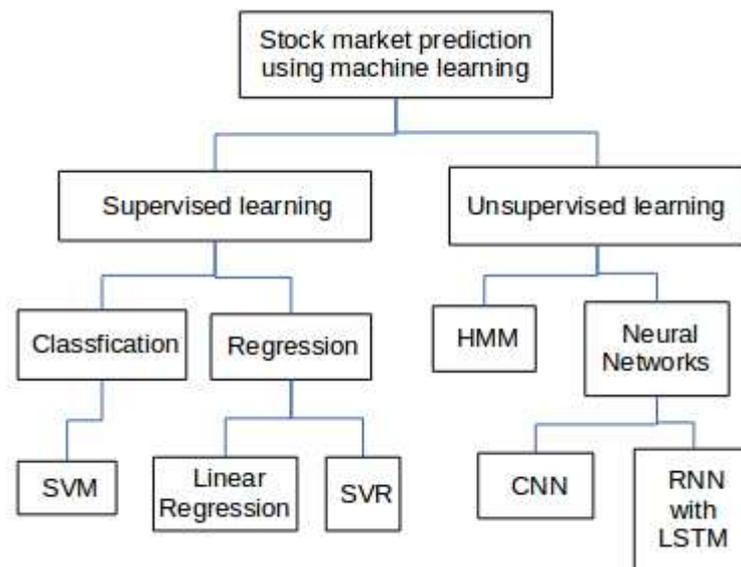


Fig 2:- Classification of stock market prediction using machine learning methods

Supervised and Unsupervised methods of machine learning require data, that they will analyze to produce certain data groups. Labeled data is used in supervised learning as input data. In unsupervised learning the data used is not labeled. Machine will categorize and label the raw data in case of unsupervised learning.

### A. Support Vector Machines

Support Vector Machines (SVM) is a kind of classification which comes under supervised statistical learning technique. SVM was one of the most common techniques that was used for prediction before the introduction of neural networks. In financial time series modeling and trend prediction we can successfully apply SVMs. By kernel mapping SVM first transforms the data to higher dimensional space and after that those mappings are given weight to obtain output and classification can be done[8]. SVM can be used successfully in stock market prediction. It was found that SVM outperforms certain regression methods like logistic regression and even some neural network methods in stock market prediction[25].

### B. Regression

A technique that can be used as a machine learning technique in stock market prediction is regression. Regression is a type of prediction method whose outcome is dependent on the given input. Based on previous information the system tries to predict a value for an input. There are different types of regression. Linear regression is the simplest regression technique whereas multiple regression is an advanced regression technique [10]. To predict the relationship in a statistical technique like linear regression between the dependent and independent variable can be expressed as  $y = mx+c$ , where  $y$  is the dependent variable and  $x$  is the independent variable,  $c$  is a constant and  $m$  is the slope of the regression line. Application of regression comes when we want to predict the next price for each of the 100 or 1000 stocks, predict the value of some index in the next  $n$  minutes etc.

### C. Support Vector Regression

In support Vector Regression (SVR) the concept is based on support vectors like in SVM, but it uses soft margins in the regression process instead of classification. An additional parameter is required to compute the loss function. Support Vector Regressors can also be used in financial time series modeling and trend prediction. Henrique et.al[11] has used a machine learning technique called SVR to predict stock prices for large and small capitalizations and in three different markets, employing prices with both daily and up-to-the-minute frequencies. It was found that the results suggest that the SVR has predictive power, when periodically using a strategy of updating the model. During low volatility periods results show increased prediction precision[11][24]. Support Vector Regression has also shown precise prediction on stock market prediction as shown in the fig. 4.

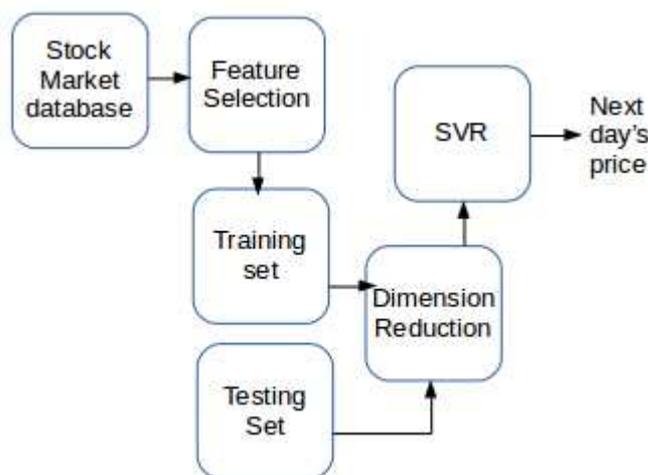


Fig. 4. Prediction of next day's price using Support Vector Regression.

D. Hidden Markov Models

Hidden Markov Models(HMM) are also used to forecast and predict the stock market. Stock market prediction is a type of time series data. In time series we provide ordered list of values of one parameter or variable in equal time intervals. Sengupta et.al [16] uses time series forecasting to predict future activity of information regarding historical values and associated patterns . We cannot guarantee success as it is with all other forecasting methods. In predicting time depending or time series phenomenon HMM are successful. Here each state is associated with a set of possible observations and based on a set of unobserved underlying states transitions occur in HMM. Stock market can also be seen as an HMM [12]. Prediction of stock data can also be done using Hidden Markov Models as illustrated in fig. 5.

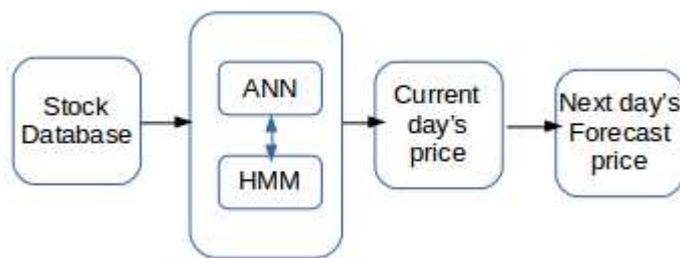


Fig.5:- Prediction of next day's forecast price using Hidden Markov Model.

E. Neural Networks

Neural networks are successful in predicting or forecasting data from a given input. In stock market prediction also we can apply neural networks successfully[19]. The past stock market data available from the internet is fed into stock price in matrix format and using optimized neural network algorithm future stock prices are predicted and we get the final output which can be pictorially represented as in fig. 6.

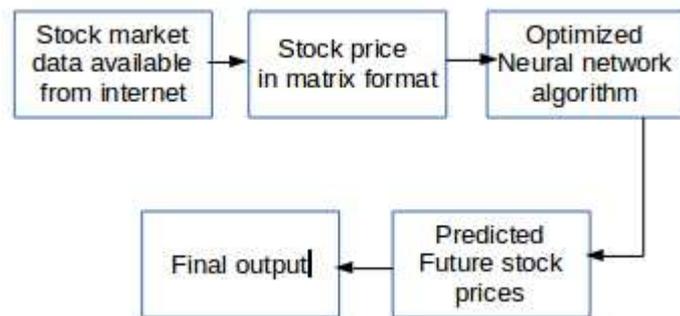


Fig.6:- Flow of data from input to output using neural network algorithm.

Deep learning is a subset of artificial intelligence which in-turn is a subset of machine learning. The algorithms in deep learning are inspired by the structure and function of brain called artificial neural networks. Some of the applications of deep learning include self-driving cars, computer vision, speech recognition and so on. With multiple levels of abstraction deep learning allows computational models that are composed of multiple processing layers to learn representations of data[13]. Deep learning can be effectively used in the prediction of stock prices [17][23]. Deep

learning includes Convolution neural networks, Recurrent neural networks with long short term memory and so on.

### E.1 Convolution Neural Networks

Convolution Neural Network (CNN) is a deep feed forward artificial neural network in machine learning. Applying CNN to stock market prediction gives more appealing results on testing. CNN networks give more accurate results on testing of stocks in stock markets. Among the basic neural network models CNN outperforms in performance[14]. One of the advantage of using convolution neural network is that it can be used effectively in time series data when transformed into visual representations.

### E.2 Recurrent Neural Networks using Long Short Term Memory

Sequence Prediction of stock market is a chaotic process. We can use machine learning techniques to model the chaotic stock market prediction. Recurrent neural network (RNN) is another machine learning technique that can be used in stock market prediction. In stock market prediction we use recurrent neural network to predict the future market based on the past in a similar way we predict a next word based on the previous one[18]. A type of RNN called Long Short Term Memory (LSTM) is a good solution but using LSTM directly on stock market prediction results in over generalization and predicts the last seen price as the next price. LSTM has cleverly designed memory that allows it to

1. Selectively choose what it remembers.
2. Decide to forget.
3. Select what amount of its memory it should output.

In using the RNN with LSTM model the features are formed from the raw stock data. The sequences obtained from the features formed are fed to the RNN LSTM model. The RNN LSTM model outputs different classes which are used in predicting the stock data. This is illustrated diagrammatically in the fig. 7.

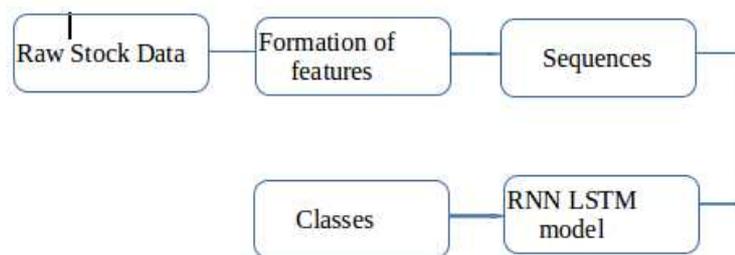


Fig. 7. Flow of data from input to output using the a RNN LSTM model.

A comparative technique showing different techniques in machine learning is shown in table 2.

Table 2. Comparative Table Showing different Techniques in Machine Learning

| Author  | Title  | Technique   | Idea  | Findings   |
|---|--|---|---|--|
| Shom Prasad Das, Sudarsan Padhy                                 | Support Vector Machines for Prediction of Futures Prices in Indian Stock Market IJCA 2012                        | Back Propagation, Support Vector Machine.         | Forecasting model is used with real index futures data collected from National Stock Exchange (NSE).              | Compared to Back Propagation Support Vector Machines provides better results.            |
| RautSushrut Deepak, Shinde IshaUday, D.Malathi                  | Machine Learning Approach in Stock Market Prediction, IJPAM 2017   | Artificial Neural Network, Support Vector Machine | Comparison of different techniques in machine learning is done in this paper.                                     | Using Support Vector Machines classifier binary classification is done.                  |
| Han Lock Siew, Md Jan Nordin                                    | Regression techniques for the prediction of stock price trend, ICSSBE, 2012                                      | Linear Regression                                 | Regression techniques are used for prediction of stock price using a transformed data set in ordinal data format. | SMO Regression technique has outperformed the other regression techniques in this paper. |
| Bruno Miranda Henrique, Vinicius AmorimSobreiro, Herbert Kimura | Stock price prediction using support vector regression on daily and up to the minute prices, Sciencedirect, 2018 | Support Vector Regression                         | Comparison of SVR with random walk model is done.   | Support Vector Regression has good predictive power compared to random walk.             |
| Aditya Gupta, BhuwanDhingra                                     | Stock Market Prediction Using Hidden Markov Models, SCES, 2012   | Hidden Markov model                               | Given historical data Maximum a Posteriori HMM approach is used for forecasting stock values for the next day.    | Hidden Markov Models is compared with ANNs using Mean Absolute Percentage Error (MAPE)   |
| YannLeCun,  | Deep learning,   | Convolution                                       | Discussion of   | Study of   |

|  |  |   |  |   |
|--|--|---|--|---|
| YoshuaBengio,<br>Geoffrey Hinton   | Nature, 2015   | neural network,<br>Recurrent,<br>Neural<br>Network  | different deep<br>learning methods.  | different<br>deep learning<br>techniques<br>is done.  |
| SreelekshmySelvin,<br>Vinayakumar R,<br>Gopalakrishnan<br>E.A, Vijay Krishna<br>Menon, Soman K.P | Stock Price<br>Prediction using<br>LSTM, RNN<br>and CNN sliding<br>window model,<br>IEEE, 2017             | Long Short<br>Term Memory,<br>Recurrent<br>Neural<br>Network,<br>Convolution<br>Neural<br>Network<br>sliding window | Performance is<br>compared with RNN,<br>LSTM and CNN<br>methods.   | Sliding<br>window<br>approach using<br>CNN for<br>predicting<br>future values<br>on a short term<br>basis is done in<br>this paper. |
| Jian-Zhou Wang,<br>Ju-Jie Wang, Zhe-<br>George Zhang,<br>Shu-Po Guo                              | Forecasting<br>stock price<br>indices with<br>Back<br>Propagation<br>Neural<br>Networks,<br>Elsevier 2011. | Wavelet<br>denoising<br>based Back<br>Propagation,<br>Single Back<br>Propagation.                                   | Experiment is carried<br>on real stock data set.<br>Data that contain<br>noise is taken into<br>account.<br>Denoisingprocess is<br>done on it. Error is<br>also also calculated. | Wavelet<br>Denoising<br>Back<br>Propagation<br>performs better<br>than single<br>Back<br>Propagation<br>model.                      |

**III METHODOLOGY**

We have used Adaptive Moment Estimation (ADAM) optimization algorithm for stock market prediction .ADAM is a combination of RMSprop and stochastic gradient descent with momentum[15]. It uses the squared gradients to scale the learning rate like RMSprop and it takes advantage of momentum by using moving average of the gradient instead of gradient itself like Stochastic Gradient Descent with momentum. Recurrent Neural Networks with Long Short Term Memory is used here.

In optimization algorithm objective function is actually a mathematical function which is dependent on the models internal learnable parameters that are used in computing the target values(Y) from the set of predictors(X) used in the model. In a particular model the internal parameters play an important role in efficiently and effectively training a model and producing accurate results. This is reason why we use various optimization strategies and algorithms. It help us to calculate and update the optimum values of models parameters which influence our models learning process and hence the output of the model.

**IV RESULTS AND DISCUSSIONS**

We have done an analysis of the techniques used in stock market prediction using machine learning. A broad classification of methods of stock market prediction includes random walk using efficient market hypothesis, fundamental analysis and artificial neural network based models.

We have used ADAM optimization algorithm for stock market prediction of Infosys, a reputed IT company based in India.ADAM works well in practice and compares favorably to other adaptive learning method algorithms as it converges very fast and the learning speed of the model is quiet fast and efficient. ADAM keeps track of the changes that previously occurred and will amplify the changes for weights that change infrequently and suppress the changes for weights that frequently changes.

Thus ADAM seems to be a promising algorithm for the stock market data.

Root Mean Square Error (RMSE) is used for testing the prediction accuracy. RMSE is square root of average of squared errors. Prediction Accuracy using RMSE value is shown in Table 3.

Table 3. Prediction Accuracy using Root Mean Square Error

| Optimization Algorithm      | Root Mean Square Error |
|-----------------------------|------------------------|
| Stochastic Gradient Descent | 2.00                   |
| Adaptive Gradient Descent   | 0.34                   |
| Adaptive Moment Estimation  | 0.23                   |

According to RMSE criterion smaller the error better the forecasting ability of that algorithm. From the RMSE value shown in Table 3 it is evident that the ADAM optimization algorithm has the lowest RMSE value.

Deep learning which comes under machine learning have contributed enormously to stock market prediction using methods such as Convolution Neural Networks and Recurrent Neural Networks using Long Short Term Memory. Recent research papers on machine learning techniques have significant contributions on the area of deep learning. RNN with LSTM is also a good solution for stock market prediction. A plot of Open, High, Low, Close (OHLC) value versus Time in days plot for Infosys stock is shown in fig 8. From fig 8 it is seen that the predicted stock price of Infosys lies very close to the actual collected value.

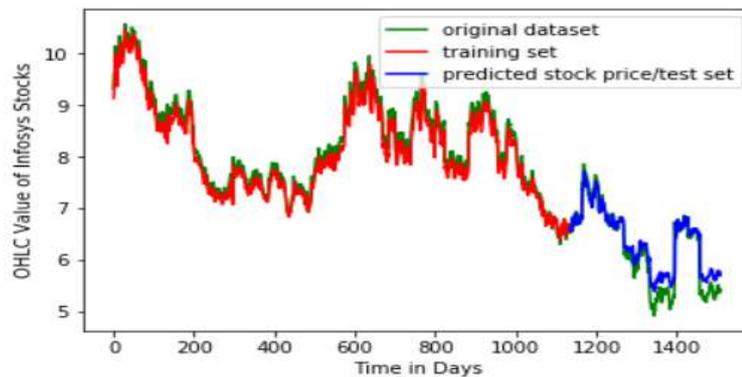


Fig. 8:- OHLC value vs Time in days plot for Infosys stock

## V CONCLUSIONS AND FUTURE SCOPE

We have given a brief overview of different machine learning techniques used in stock market prediction. A comparative analysis of different machine learning techniques for stock market prediction is done. Recent studies shows that deep learning methods outperform other methods of machine learning. In this paper we have studied the effect of the optimization algorithm, Adaptive Moment Estimation (ADAM) in stock market prediction and prediction accuracy using Root Mean Square Error is computed. Open, High, Low, Close (OHLC) average is used to build the model and prediction. In our future work we will implement the problem using other variants of the optimization algorithm. We can also use accuracy prediction methods

such as Mean Absolute Percentage Error (MAPE). The performance can be compared and the results can be analyzed.

## REFERENCES

- [1] Kimoto, T., Asakawa, K., Yoda, M., & Takeoka, M. (1990, June). Stock market prediction system with modular neural networks. In *Neural Networks, 1990., 1990 IJCNN International Joint Conference on* (pp. 1-6). IEEE.
- [2] Fama, E. F. (1991). Efficient capital markets: II. *The journal of finance*, 46(5), 1575-1617.
- [3] Kavussanos, M. G., Dockery, E. (2001). A multivariate test for stock market efficiency: the case of ASE *Applied Financial Economics*, 11(5), 573-579.
- [4] Qian, B., Rasheed, K. (2007). Stock market prediction with multiple classifiers. *Applied Intelligence*, 26, 25-33.
- [5] Zhang, Y., Wu, L. (2009). Stock market prediction of S and P 500 via combination of improved BCO approach and BP neural network. *Expert systems with applications*, 36(5), 8849-8854.
- [6] Fama, E. F., Fisher, L., Jensen, M. C., Roll, R. (1969). The adjustment of stock prices to new information. *International economic review*, 10(1), 1-21.
- [7] Guresen, E., Kayakutlu, G., Daim, T. U. (2011). Using artificial neural network models in stock market index prediction. *Expert Systems with Applications*, 38(8), 10389-10397.
- [8] Das, S. P., Padhy, S. (2012). Support vector machines for prediction of futures prices in Indian stock market. *IJCA*
- [9] Deepak, R. S., Uday, S. I., Malathi, D. *Machine Learning Approach in Stock Market Prediction*.
- [10] Siew, H. L., Nordin, M. J. (2012). Regression techniques for the prediction of stock price trend. *Statistics in Science, Business, and Engineering (ICSSBE) Langkawi Universiti Kuala Lumpur*, 1-5.
- [11] Henrique, B. M., Sobreiro, V. A., Kimura, H. (2018). Stock Price Prediction Using Support Vector Regression on Daily and Up to the Minute Prices. *The Journal of Finance and Data Science*.
- [12] Gupta, A., Dhingra, B. (2012, March). Stock market prediction using hidden markov models. In *Engineering and Systems (SCES), 2012 Students Conference on* (pp. 1-4). IEEE.
- [13] LeCun, Y., Bengio, Y., Hinton, G. (2015). Deep learning. *Nature*, 521(7553), 436.
- [14] Selvin, S., Vinayakumar, R., Gopalakrishnan, E. A., Menon, V. K., Soman, K. P. (2017, September). Stock price prediction using LSTM, RNN and CNN-sliding window model. In *Advances in Computing, Communications and Informatics (ICACCI), 2017 International Conference on* (pp. 1643-1647). IEEE.
- [15] Kingma, D. P., & Ba, J. (2014). Adam: A method for stochastic optimization. *arXiv preprint arXiv:1412.6980*.
- [16] Sengupta, I., Chaudhury, S. (2018). Stock Market Prediction Using Time Series Analysis. *Expert Systems with Applications*, 38(11), 14346-14355.
- [17] Khare, K., Darekar, O., Gupta, P., Attar, V. Z. (2017, May). Short term stock price prediction using deep

- learning. In Recent Trends in Electronics, Information Communication Technology (RTEICT), 2017 2<sup>nd</sup> IEEE International Conference on (pp. 482-486). IEEE.
- [18] Sureshkumar, K. K., Elango, N. M. (2011). An efficient approach to forecast Indian stock market price and their performance analysis. *International Journal of Computer Application*, 34(5), 44-49.
- [19] Rather, A. M., Agarwal, A., Sastry, V. N. (2015). Recurrent neural network and a hybrid model for prediction of stock returns. *Expert Systems with Applications*, 42(6), 3234-3241.
- [20] Sutskever, I., Vinyals, O., Le, Q. V. (2014). Sequence to sequence learning with neural networks. In *Advances in neural information processing systems* (pp. 3104-3112).
- [21] Yetis, Y., Kaplan, H., Jamshidi, M. (2014, August). Stock market prediction by using artificial neural network. In *World Automation Congress (WAC)*, 2014 (pp. 718-722). IEEE.
- [22] Keneshloo, Y., Shi, T., Reddy, C. K., Ramakrishnan, N. (2018). Deep Reinforcement Learning For Sequence to Sequence Models. arXiv preprint arXiv:1805.09461.
- [23] Iqbal, Z. (2013). Efficient Machine Learning Techniques for Stock Price Prediction. *Int. Journal of Engineering Research and Applications*, 3(6), 855-867.
- [24] Guo, Z., Wang, H., Liu, Q., Yang, J. (2014). A feature fusion based forecasting model for financial timeseries. *PloS one*, 9(6), e101113.
- [25] Di Persio, L., & Honchar, O. (2016). Artificial neural networks approach to the forecast of stock market price movements. *International Journal of Economics and Management Systems*, 1.