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Comparison of Stock Price Prediction Models using Pre-trained Neural Networks

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Abstract

Several intelligent data mining approaches, including neural networks, have been widely employed by academics during the last decade. In today's rapidly evolving economy, stock market data prediction and analysis play a significant role. Several non-linear models like neural network, generalized autoregressive conditional heteroskedasticity (GARCH) and autoregressive conditional heteroscedasticity (ARCH) as well as linear models like Auto-Regressive Integrated Moving Average (ARIMA), Moving Average (MA) and Auto Regressive (AR) may be used for stock forecasting. The deep learning architectures inclusive of Convolutional Neural Network (CNN), Long Short-Term Memory (LSTM), Recurrent Neural Networks (RNN), Multilayer Perceptron (MLP) and Support Vector Machine (SVM) are used in this paper for stock price prediction of an organization by using the previously available stock prices. The National Stock Exchange (NSE) of India dataset is used for training the model with day-wise closing price. Data prediction is performed for a few sample companies selected on a random basis. Based on the comparison results, it is evident that the existing models are outperformed by CNN. The network can also perform stock predictions for other stock markets despite being trained with single market data as a common inner dynamics that has been shared between certain stock markets. When compared to the existing linear models, the neural network model outperforms them in a significant manner, which can be observed from the comparison results.

Keywords: neural network, data prediction, deep learning, stock market, data mining

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1. Introduction

A stock market is where stocks and shares of a company are traded [1]. The market is divided into two parts: main and secondary. Initial Public Offerings (IPOs) bring new securities to the primary market. Securities that investors already hold are exchanged in the secondary market [2]. In the stock market, a non-linear and highly changing time series data is observed [3]. For a specific activity, the status acquired by measuring the data over a period of time is termed as time series. Stock market forecasting is performed by using linear models like Auto-Regressive Integrated Moving Average (ARIMA), Moving Average (MA) and Auto Regressive (AR) [4]. However, in this case, a model identified for a specific organization may not be used for another organization as it works only for a specific time series data. When compared to other sectors, higher risks are observed in stock market forecasting due to the market's unforeseeable and equivocal nature [5]. The challenges in stock market prediction is a significant outcome of this reason. These disadvantages can be solved by using deep learning models into financial forecasting [6].

Combination of deep learning models and neural network architecture provides the deep neural network [7]. Artificial neural network (ANN) is a type of deep neural network that can generalize and learn from experience and provide good approximation. The characteristics of ANN that helps to successfully overcome the forecasting issues in practical applications includes the ability to examine the input output relationship despite facing complex datasets by providing good function approximation and the ability to identify new test samples that are not used for training the network [8]. Stock market prediction is performed by using ANN over the past few decades. Prediction of stock market using various DL models and their comparison has been performed by several researchers. Further, directive and iterative schemes for forecasting are experimented [9]. Stock market prediction using recurrent neural network (RNN) with low complexity is also proposed. The stock market input parameters are provided for the prediction of National Association of Securities Dealers Automated Quotations

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(NASDAQ) stock values using ANN. RNN and back propagation are used for multiple stock market return analysis [10].

The company stock value are predicted by using Elman Recurrent Network and feed forward Multi-Layer Perceptron (MLP) are compared in a study [11]. A prediction model for technical analysis using neural network is utilized. In stock market forecasting, the efficiency of ANN is analyzed and estimated. For 50 listed nifty companies, the stock price and volume as well as their interdependency is explored. For time series analysis, various DL models and their applications are studied [12]. Financial time series analysis and natural language processing (NLP) combination is studied from application perspective. Stock market prediction using Particle Swarm Optimization (PSO), Least Square Support Vector Machine (LSSVM) and other ML algorithms is analyzed. Stock price forecasting using ANN based feature discretization using Genetic Algorithm (GA) is introduced for prediction of stock market [13]. Stock trends forecasting is performed using wavelet transform and multi-stage fuzzy inference. Wavelet transform is used for describing the stock trends and their short-term features [14].

2. Event-based Trading

For investment management, a strong trend has emerged by means of algorithmic trading for processing voluminous data by computers using the growing computational power in recent years [15]. The investment strategies are framed using information from unstructured text data by means of natural language processing in combination with machine learning. Opinion mining and sentiment analysis has largely influenced stock market prediction in the NLP domain. Trading volume and market prices are affected by media pessimism according to the sentiment analysis performed to estimate the correlation among market prices, news articles and sentiment [16]. Twitter feeds are used for estimating the collective mood, which has exhibited the average closing values of Dow Jones Industrial to be highly predictable. For the purpose of stock market forecasting, social media information is also used in certain research literature [17].

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For direct stock price forecasting, many feature selection algorithms based on news items are provided. When noun phrases were utilized for feature extraction from financial news articles using support vector regression for sentiment evaluation, very limited success was observed [18]. Subjectivity scale based positive or negative score is obtained in this regard. News articles on online stock market are used for the identification of words with similar emotion compared to a set of seed words and their corresponding intensities based on a contextual entropy selection mechanism to achieve an improved accuracy. N-gram feature based feature selection with binormal separation and chi-square are applied for attaining the improved results [19]. Negation scope is a challenge with sentimental analysis. Negation scope may be predicted by using reinforcement learning technique in the financial news datasets for accuracy enhancement. Impact scores defined by experts, the news based events extracted and other technical indicators are used for combining trading rules with evolutionary algorithm in stock trading strategies for news incorporation [20]. Optimal trading strategies are also dependent on news events despite being a non-optimal way for data extraction from financial text data.

3. Deep Learning Models

When compared to biological neurons, similar computational structure is observed in ANN. Generalization from an underlying trend that is identified is the basic operation of the model. ANN is a statistical non-linear information analysis module [21]. ANN can be used for modeling the inputs and outputs with respect to the intricate relationship between them. In scenarios where conventional methods are unsuccessful, the underlying data patterns may be learnt by using ANN. Input, hidden and output layer are the three layers of ANN. Except the input layer, the output and hidden layers make use of the non-linear activation functions. The neurons in the input layer of each node are connected to the following hidden layer and the output layer [22]. In classification challenges involving two-groups and classification algorithms, a supervised machine learning technique called SVM is used. New text data may

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be categorized using Support Vector Machine (SVM) by training the model for each category with a set of labelled data. Figure 1 represents the basic flow diagram of SVM [23].

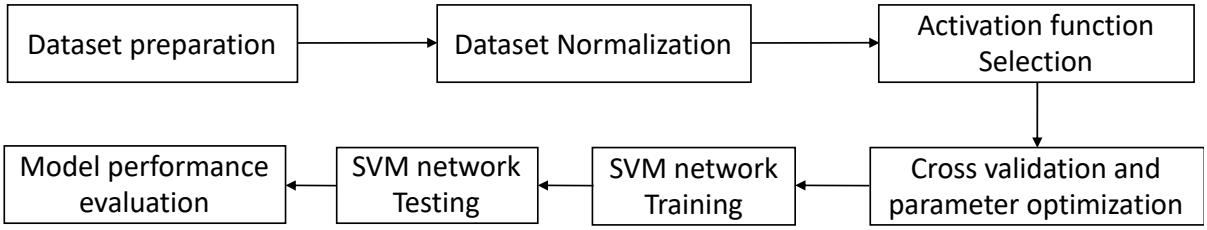

Figure 1. Basic SVM Flow Diagram

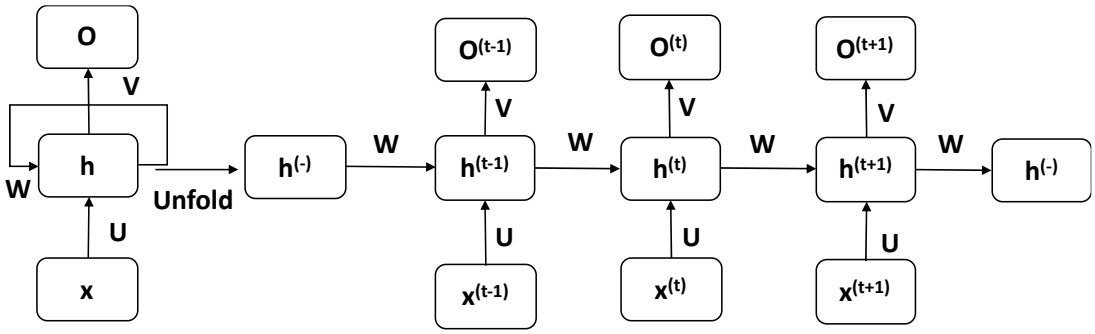

Figure 2. Basic RNN Architecture

Another simple neural network example is MLP, which is a feed forward network. A weighted matrix is used for linking every input neuron to the neurons in the following hidden layer [24]. The input, output and hidden layer sections are available in each network. The output and hidden layers consist of artificial neurons. Inputs are received from the previous layer at each of these neurons. Neurons within a network are connected with those form the next layer. However, neurons within the same layer are not connected. Input is obtained from two sources for RNN, unlike MLP. The basic RNN architecture is represented in Figure 2. The present and past data is used for this purpose. For a new data set, the response of the model with data from the two sources is checked. At each instant, the output acts as an input to the next instant in the feedback loop [25]. A memory is available in the RNN. The recurrent network's hidden state stores the information regarding each input sequence. As new information is fed to the network, recursive use of the hidden information is performed by the network.

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Another special type of RNN is the Long Short-Term Memory (LSTM). Information regarding long-term dependencies are learnt using these networks. In 1997, Schmidhuber and Hochreiter introduced this network [26]. Figure 3 represents a basic LSTM cell where x_t represents the input and h_t is the output. The forget, input and output gates are represented by f_t, i_t and o_t respectively. u_t and c_t gives the cell update and cell state respectively. Long term dependency issues may be evaded using the design of these networks, while the normal operation involves storage of data for long time duration. When compared to the other neural networks, the structure of LSTM is different [27]. Rather than a single neural network layer, cells or memory blocks are available in the LSTM while a feedback loop with simple neural network is seen in conventional RNN. Data flow through cells are regulated using cell state. 3 gates are available in each block or cell.

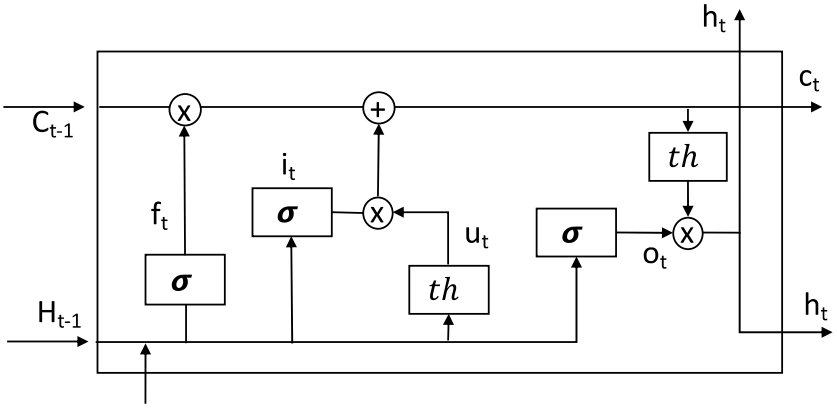

Figure 3. Basic LSTM Cell

4. Results & Discussion

Telecom, manufacturing, banking and IT sectors are considered for obtaining highly traded stock datasets from NSE. Stocks from Bharti Airtel, Tata steel, HCL, Infosys and Bajaj Fiserv are taken for this purpose. Information such as number of trades, turnover, total trade quantity, average, closing, last, low, high and opening prices, previous closing, stock date, stock series and stock symbol are considered. The market closing price of the stock is used for making decision on the stock by investors. For this purpose, day wise stock price is considered

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and for every stock, the day-wise closing price is extracted from the datasets. Further, training, window size fixing and testing of the models has been performed. The Telecom based Bharti Airtel dataset is used for training purpose. Data from the period of July 2019 to July 2021 is used containing the closing price of 496 days. 323.9 to 608.85 is the range of the training data. Data unification is performed within the range 0 to 1 for normalization of the extracted data.

Window size is fixed based on the prediction days and Mean Absolute Percentage Error (MAPE). Rest of the data is used for testing the system on extraction of date wise stock closing price for each stock. The output is predicted by data normalization and de-normalization similar to the process done with the training dataset. Linear model ARIMA is used for non-linear and linear model comparison.

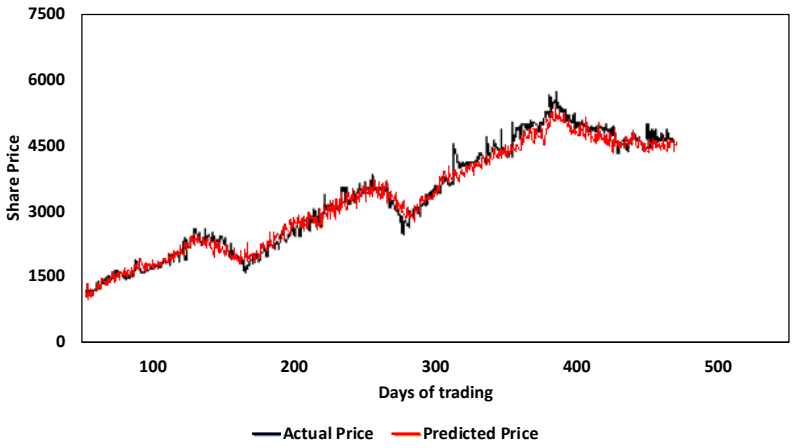

Figure 4. Bharti Airtel Stocks- Real and Predicted Values using RNN

Figure 4, 5 and 6 provides the comparison of real and predicted stock values of Bharti Airtel, Tata Steel and Bajaj Fiserv using RNN, MLP and CNN models respectively. Similar comparison is performed for all combinations. From these results, the accuracy is compared and it is found that CNN model outperforms the other models. Certain models however, failed to capture the system variations in specific time intervals. MLP and RNN showed similar patterns in the former stages. When compared to the actual values, the predicted values showed

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a lag when LSTM is used. Error calculation component may be included in the neural network models for further learning process.

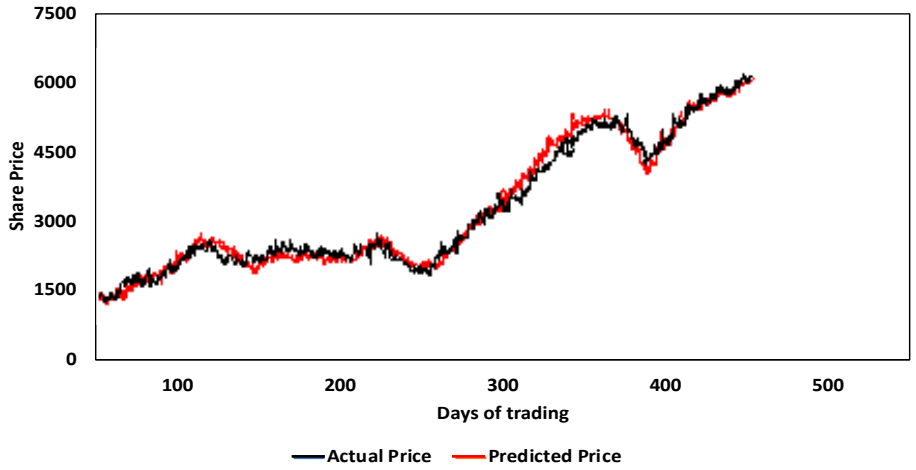

Figure 5. Tata Steel Stocks- real and predicted values using MLP

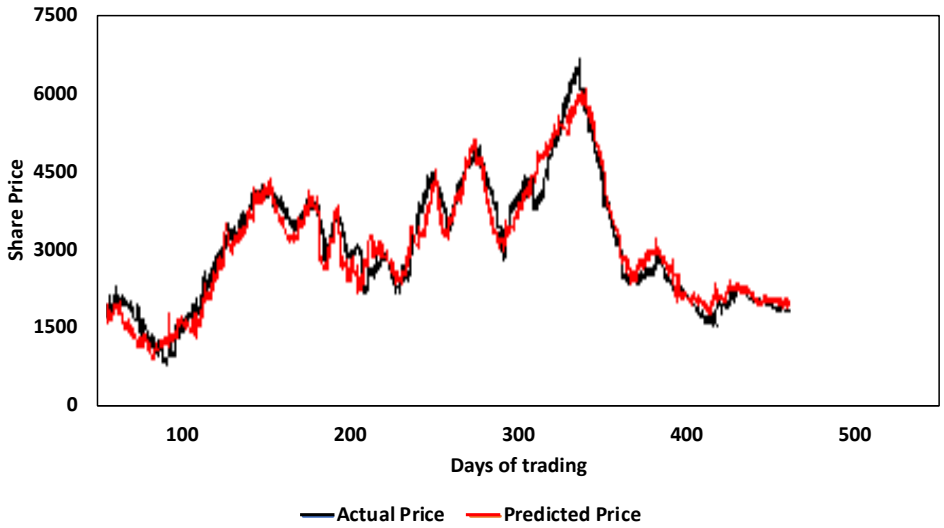

Figure 6. Bajaj Fiserv Stocks- real and predicted values using CNN

Highly non-linear and voluminous data is generated by the stock market. The underlying dynamics and hidden patterns must be analyzed for modeling this dynamic data. Self-learning process is used for identification and exploitation of the patterns and interactions between the available data by means of deep learning algorithms. The hidden patterns and

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interactions of the data may be analyzed while providing near accurate predictions for such data using deep learning models in an efficient manner unlike other conventional models. Stock returns are predicted using various input variables using neural network models for analysis of financial time series. The input may be fed from data obtained based on a single time series or from macroeconomic variables or heterogeneous market information. The NLP and the analysis of financial time series combination also offers good performance. The multivariate time series financial data can also be modeled using deep learning architectures. Further, prediction and analysis of technical variables with different weight initialization schemes can also be performed using neural network model. Weight initialization using multiple linear regression and conjugate grading learning improves the performance efficiency of back propagation model.

5. Conclusion

In this study, the globally leading stock market NSE stock price prediction is conducted by utilizing five deep learning architectures. The stock price of Bharti Airtel is used to train CNN, LSTM, RNN, MLP, and SVM networks. The stock prices of Tata Steel, HCL, Infosys, and Bajaj Fiserv are acquired from the NSE stock market and compared to the stock prices projected using the derived models. The experimental findings demonstrate that pattern recognition is attainable in an effective way, when the industry's pattern is used over the others. It may also be applied to other stock markets that have similar fundamental characteristics. The underlying dynamics of numerous time series cannot be discovered using linear univariate time series prediction models like ARIMA. The experimental findings show that the ARIMA model is outperformed by the DL models. The following instant may be predicted by using a specific window as abrupt changes in the system are captured using CNN model in a more accurate manner when compared to the other techniques in the proposed work. Future work is directed towards combining multiple networks to form a hybrid network for improving the prediction accuracy.

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