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Short Term Stock Price Prediction Using Deep Learning

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Abstract—Short - term price movements, contribute a considerable measure to the unpredictability of the securities exchanges. Accurately predicting the price fluctuations in stock market is a huge economical advantage. The aforementioned task is generally achieved by analyzing the company, this is called as fundamental analysis. Another method, which is undergoing a lot of research work recently, is to create a predictive algorithmic model using machine learning. To train machines to take trading decisions in such short - period of time, the latter method needs to be adopted. Deep Neural Networks, being the most exceptional innovation in Machine Learning, have been utilized to develop a short-term prediction model. This paper plans to forecast these short - term prices of stocks. 10 unique stocks recorded on New York Stock Exchange are considered for this review. The review essentially focuses on the prediction of these short - term prices leveraging the power of technical analysis. Technical Analysis guides the framework to understand the patterns from the historical prices fed into it, and attempts to probabilistically forecast the fleeting future prices of the stock under review. The paper discusses about two distinct sorts of Artificial Neural Networks, Feed Forward Neural Networks and Recurrent Neural Networks. The review uncovers that Feed Forwards Multilayer Perceptron perform superior to Long Short-Term Memory, at predicting the short - term prices of a stock.

***Keywords—D*eep Learning, Artificial Neural Networks, Multilayer Perceptron, Stock Price Prediction, Technical Analysis**

I. Introduction

As of late estimating stock prices is increasing in more consideration, perhaps in view of the way that if the prices are effectively anticipated the traders might have proper direction while taking decisions. The profit returns realized from stock markets heavily depend on market analysis. If by any chance any framework be created which can reliably forecast the prices of the dynamic securities exchanges, it would make the proprietor of the framework well off. Moreover, such predictions will assist the controllers of the market in planning restorative measures in extreme cases.

Another inspiration for this research work is that it has numerous hypothetical and test challenges. One such critical hypotheses is the Efficient Market Hypothesis (EMH)[1].The hypotheses cites that in a proficient market, stock prices completely reflect accessible data about the market and its constituents and hence any chance of acquiring over abundance benefit stops to exist. However, there exists a counter postulate called Inefficient Market Hypothesis (IMH), which presents that monetary markets are not constantly productive, the market is not generally in a random walk, and inability exists[2].

Numerous scientists and specialists have proposed many models for stock price prediction, utilizing different fundamental, technical and analytical methodologies. Fundamental analysis includes the comprehensive reasoning in terms of extrinsic macroeconomic factors to address the changes in stock prices. The examination of the financial variables is subjective as the elucidation absolutely lays on the intelligence of the analyst. On the other hand, technical analysis fixates on utilizing value, volume, and other financial factual graphs to foresee stock developments. The preface to technical analysis is that the greater part of the intrinsic and extrinsic elements, which influence a market at any instance of time are already calculated into the market's cost[3].

With the hope of predicting market's movements, utilization of neural networks in securities exchange forecasting problems is extremely encouraging because of some of their exceptional qualities.

Firstly, neural networks exhibit striking capacity to extract context from convoluted or estimated information. They are utilized to derive patterns and identify trends that are too convoluted to be in any way be comprehended by either humans or other conventional computer processes.

Secondly, neural networks exhibit a nonlinear nature and are favored over the conventional linear models.

Thirdly, a neural network trained to a specific dataset of a specific domain; can be effortlessly re-trained to another condition to forecast at similar level of conditions. Also, when the framework in review is continuously changing and updating, neural networks have the capability to accordingly alter their weights.

Stock market in itself is a highly non-linear, perplexing, dynamic and perpetually evolving framework. Neural networks, with the majority of their, aforementioned features, are the ideal answer for forecasting price of stock market.

II. Literature Review

This review requested a lot of study and analysis to be donein both fields viz. Deep Learning and Financial Theories

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relating to technical indicators, trading strategies, stock market data and its analysis.

The applications of Deep Learning in different financial domains was explained by J. B. Heaton and his colleagues [4]. Their study discussed a few prediction problems in the financial domain. It also stated a few advantages deep learning predictors have over traditional predictors. A few of them being, over fitting can be easily avoided and correlation in input data can also be handled easily.

Recently, the research world has seen a lot of different algorithms and different types of neural networks being developed. Finding the perfect neural network for one's research is a mammoth task. It requires a lot of study and analysis. Our review also required us to study about different types of neural networks and choose the one which best suits our problem statement. Torkil Aamodt in his thesis [5], found that Support Vector Regression, Feed Forward Neural Network and Convolutional Neural Network had comparable results and Echo State Network had noisy behavior.

LSTMs had been conventionally proven successful for time series prediction. Hengjian Jia found that LSTMs learn patterns effective for stock market prediction and he obtained decent RMSEs with different architectures of LSTM [6]. This study helped us realize this problem as a time-series problem, and gave an insight to solve this problem with a sliding window approach.

H.B. Hashemi with his colleagues, in their research work stated that MLPs perform superior to LSTMs at prediction stock prices [7]. Their study focused on inter day price prediction. We thought of scaling this observation to our problem of short-term price prediction.

Pradeep Mahato, in his research work had developed various ensemble models to predict the movements of the next day's stock price [8].

Our Feature Engineering process, followed a heuristic method of study and analysis, which involved a lot of review of the related work as well as a lot of understanding of what stock market analysts use in real life. This process required a lot of insights into trading strategies, feature engineering and basic concepts of stock market. Interaction with industry experts provided us with those insights.

After studying the papers mentioned above, it is safe to conclude that the domain of short term stock price prediction hasn't yet been explored at depth. The results published by the same studies have also not attained the required accuracy in order to really have success in the intraday trading market.

III. Methodology

In machine learning, many a times it has been noted that the simplest of algorithms give astounding results than the complex algorithms. We have adopted this line of thinking and for the same reason, the paper will be utilizing Feed Forward Multilayer Perceptron and Long Short-Term Memory model. The two models would be trained on the same data and would be made to predict short-term stock prices and their results would be discussed in the following sections.

A. Multilayer Perceptron(MLP) Neural Network

MLP consists of a network of densely connected neurons between adjoining layers. One of the peculiarities of Feed Forward Neural Networks is that output of one layer is never fed back to the previous layers. The input which goes to every neuron is the weighted sum of all the outputs from the previous layer of the neural network. The conversion of this input into the output is performed by a continuous and differentiable activation function. The output of one pass is produced after the signals propagate from input to the output layer. The error for the pass is calculated, for regression it is usually root mean squared error or mean squared error. The learning algorithm, generally a kind of gradient descent algorithm, adjusts the weights of the neurons necessary to reduce the error. The data is passed to the model several times to adjust the weights to reduce the errors until the preset number of epochs are reached.

B. Long Short – Term Memory(LSTM) Neural Network

LSTMs are a kind of RNNs which effectively capture long term dependencies in time series prediction problems. It is due to these dependencies that the order of input plays a significant role prediction. The steps followed in the overall algorithm of LSTM is the same as MLP except for the processing of input inside every neuron.

Unlike normal neurons, the output of every LSTM cell is a result of a multistep process. LSTMs have an additional memory, called cell state, which stores relevant past information toaid in prediction. The information stored in the cell state is modified by structures, called gates, in the following steps. Initially, the forget gate decides whether to eliminate any available information. The input gate and tanh layer then decide which new information is to be stored. Further, the information gets added and deleted according to the previous gates. Finally, the activation function is applied to the data and the output is produced.

IV. Proposed Approach

Though deep neural networks have been proven to be very powerful, creating an optimum network is an arduous task. Performance of the network is markedly dependent upon its width(number of neurons per layer), depth(number of hidden layers), activation function, training algorithm, feature set and input data.

This section will shed some light on our proposed approach to predict the short-term stock prices using MLP and LSTM model.

A. Data

Since this research project aims to predict short term stock price changes, one of its focal points is the granularity of the data used. It is a minute by minute stock price data for all the trading days of 10 stocks, listed on the New York Stock Exchange, over a period of 1 year. The data of each stock consists of approximately 85000 - 90000 points. The data was normalized into the range of [0, 1] using MinMaxScaler(2), since neural networks are known to be sensitive to unnormalized data, which is then fed to the prediction model.

$$X_{std} = \frac{X - X_{min}}{X_{max} - X_{min}}$$

$$X_{scaled} = X_{std} * (\max - \min) + min \qquad (1)$$

where $\min = 0,\ max = 1$.

B. Features

Choosing appropriate features is a very crucial factor in any prediction model. Various technical financial indicators were heuristically chosen as features in the model. The financial indicators used can be categorized into the following three types:

1) Trend Type – These indicate whether the price is bullish or bearish and consist of moving average(short), moving average(long), exponentially weighted moving average(EWMA) and moving average deviation rate(MAD).

2) Oscillator Type – These indicate the possibility of reversal an ongoing trend. This type includes indicators like moving average convergence/divergence(MACD), rank correlation index(RCI) and relative strength index(RSI).

3) Momentum Type – These indicate the rate of change of a price of the security. This includes momenta with different window sizes.

Apart from these, features also included close prices of the past few minutes.

C. Model Architecture

The review focuses on two different types of Deep Neural Networks - Feed Forward Neural Network and Recurrent Neural Network. The review utilizes Multilayer Perceptron and Long Short-Term Memory models from each of the aforementioned types of neural networks. Refer Figure 1 for general architecture of neural networks used.

1) Long Short-Term Memory (LSTM) Model – This model uses a four hidden layer stacked stateful LSTM neural network in which the input layer gets the input dataset consisting of the features mentioned above. In each hidden layer, there are h cells which are completely connected to the input and output layers. Output layer consists of one cell, which had the output for the predicted price of the second minute from the current instance. The model was architected to be stateful to use the most important feature of LSTMs which is remembering the previous states since in stock price prediction the previous prices play a significant role in predicting the future prices. Here a sliding window approach was utilized, where in a window of past 20 prices was considered. This approach made us treat this problem as a time-series prediction problem, and as mentioned previously LSTMs have been conventionally very successful for various time-series prediction problems.

2) MultilayerPerceptron (MLP) Model –Very similar to the LSTM architecture, MLP uses a four hidden layer deep network, where in the input layer and the output layer have the similar number of neurons and similar functionalities as LSTM. Here, each hidden layer consists different number of neurons. Unlike LSTMs, MLP can't be used to treat prediction problems as time-series problems. So here, we used a different prediction strategy. Here a very simple approach was followed, wherein the price of the stock for the second minute from the current instance was predicted.

V. Result and Analysis

In this section, the results of the methodologies discussed in the sections above will be analyzed. The results have been obtained from the test data, which is 30% of the entire data set of the past one year. The model had a validation split, while training phase, to avoid over fitting.

First, we will analyze the individual results of LSTM and MLP model, and later compare their performances. Both the models were trained on the same data set, which has been discussed in the previous section.

A. LSTM Model

As depicted by the graph in Figure 2, the LSTM model is successful in predicting the future price trend, upward or downward, at almost all the points. But the model fails to predict the exact price with the required accuracy. In the Figure 2 the blue and orange plots represent the actual and predicted prices respectively.

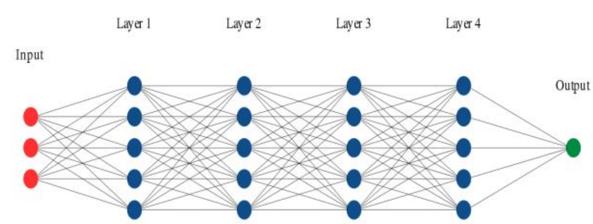

Figure 1: General Architecture of neural network used

Figure 2: Average case graph of LSTM model's predicted vs actual price

B. MLP Model

As depicted by the graphs in Figure 3 and Figure 4, the MLP model is able to capturethe future trends, upward ordownward, while also predicting the prices with an extremely high level of accuracy as compared to the LSTM model. In Figures 3 and 4 the blue and orange plots represent the actualand predicted prices respectively. As seen from both the graphs in the figures, at various points, the predicted price coincides with the actual price and the scale on Y-axis being$0.01 aids in depicting the closeness between the actual and predicted values.

As seen from the data mentioned in the Table 2, it is safe to say that the predicted value of close price, and the actual close price are extremely close to each other. This means that any position that the trader wishes to take after considering the predicted values, will never turn into huge losses.

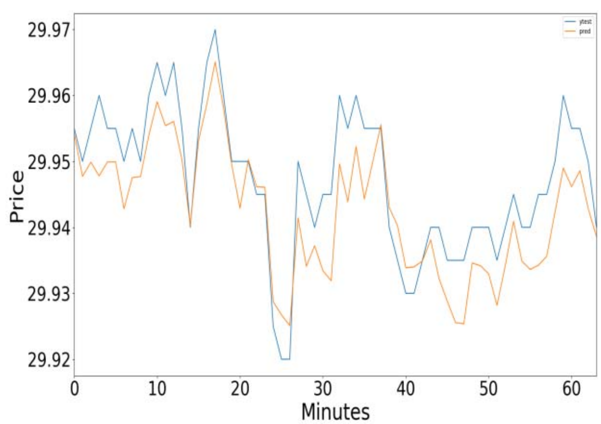

Figure 3: Average case graph of MLP model's predicted vs actual price

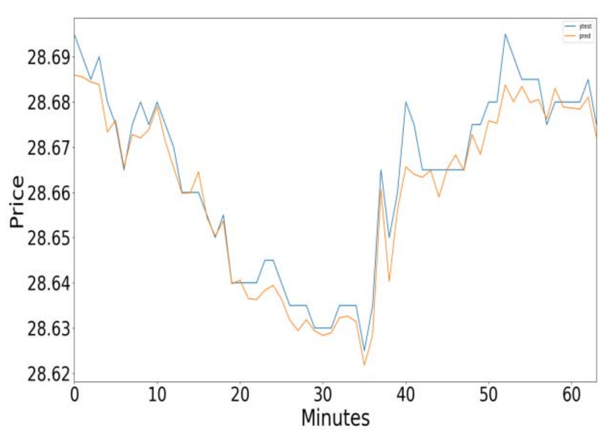

Figure 4: Best case graph of MLP model's predicted vs actual price

C. Comparative Study

The Table 1 gives a comparison between the two aforementioned models. The tool used for comparison is Root Mean Squared Error (RMSE) and this recorded error is the test error. The values in the table clearly show that MLPs have performed better than LSTM at short term stock price prediction.

LSTM		MLP	
Average Case	Best Case	Average Case	Best Case
$4.8 * 10^{-2}$	$1.88 * 10^{-2}$	$2.5 * 10^{-3}$	$9.37 * 10^{-4}$

Table 1: Comparison of RMSEs of MLP and LSTM model

Minutes	Actual Price	Predicted Price
1	29.955	29.954
2	29.950	29.947
3	29.955	29.949
4	29.960	29.947
5	29.955	29.949
6	29.955	29.949
7	29.950	29.942
8	29.955	29.947
9	29.950	29.947
10	29.960	29.955

Table 2: Actual and Predicted prices for MLP model

VI. Conclusion

This research project is our attempt to shed some light on the power of neural networks as a proficient prediction tool. Thepaper consists of a comparative study between Long Short-Term Memory (LSTM) model and Multilayer Perceptron(MLP) model. One of the key steps involved while building both the models is feature engineering. The features derived from the heuristic method of analysis and study followed in this paper are optimal for stocks which are highly frequently traded.

By leveraging the power of Deep Learning, it is possible to beat the EMH Theory to some extent. This project assists many other research projects in proving the postulates of Inefficient Market Hypotheses.

As seen from the results, MLP has outperformed LSTM model, in predicting short term stock prices. Neural networks have proved to be a good tool, to forecast a chaotic framework like Stock Market. We hope our work makes a positive impact on the study of prediction tools being built for intraday trading, which requires trading at extremely short time intervals nullifying time required for decision making.

In future works of this review, we wish to extend this model to run on tick by tick data for Indian Stock Markets and create a complete platform to execute trades based on these predictions in real time.

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