

# Optimal Neural Network Architecture for Stock Market Forecasting

*A seminar report submitted*

*by*

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# ABSTRACT

Stock market has always intrigued the market and business analysts. It's near accurate prediction is of extreme importance. Traditional parameters like Price/Earning ratio are used to predict the stocks but they are not always accurate and this brings the need of machine learning and data analysis techniques to come into picture and solve the problem. The analysis of data is possible in temporal domain because of the advancements in artificial neural networks. Time series analysis helps us to predict the data in future by studying the behaviour of data in the past. The use of feed forward backpropagation neural networks are being used to predict the stock and they give an accuracy of about 58%.

The data set contains stock prices as a time series. Stock prices are affected by many varied and non deterministic features like economic factors, confidence of people in general and so different factors like Earnings Per Share are taken into account to come up with an optimal neural network architecture which can predict the future value of stock based on present values and past trends.

The study takes into account many different non-deterministic factors to come up with the best artificial neural network architecture in terms of number of hidden layers and number of neurons in each layer. The results obtained increases the accuracy of prediction and can guide the buyers whether to buy or withhold the stocks.

**Keywords:** Stock, Artificial Neural Network, Time Series Forecasting, Optimal Structure.

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## ABBREVIATIONS

|      |   |                                   |
|------|---|-----------------------------------|
| ANN  | : | Artificial Neural Network         |
| EPS  | : | Earning Per Share                 |
| SVM  | : | Support Vector Machine            |
| P/E  | : | Price Earnings Ratio              |
| P/D  | : | Price Dividend Ratio              |
| BH   | : | Buy and Hold                      |
| SO   | : | Stop and Objective                |
| NNBH | : | Neural Network buy and hold       |
| NNSO | : | Neural Network Stop and Objective |
| TSF  | : | Time Series Forecasting           |
| ARMA | : | AutoRegressive Moving Average     |

# NOTATIONS

$\sigma$  : Standard deviation

p : Probability for a given statistic model that rejects the null hypothesis



# Chapter 1

## Introduction

### 1.1 Stock Market

Stock market has been deeply studied by human beings. It is an intriguing money making field but at the same time it creates a lot of confusion as when to buy and sell stocks. It depends on a lot of stochastic factors which are hard to determine. [1]

The value depends on a lot of factors like current trends, national and international economic situation, financial policies etc. It is of extreme importance to analyze these trends and find a correlation between these factors to come up with a dominating factor which affects the stock values the most. It has been determined experimentally that Support Vector Machine figure 1.1 gives an accuracy of 58 % which predicting the stock closing values.

The stocks of different companies are analyzed based on various internal and external factors. After representing them as a financial time series, they are fed into a multilayer back-propagated neural network. The future value is extrapolated after calculating the non-linear correlation between the input factors.

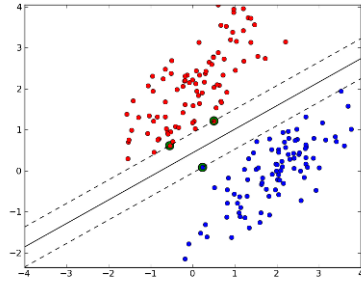


Figure 1.1: Support Vector Machine

## 1.2 Indicators of prediction

It is very evident how stock market plays a pivotal role in the economy of companies and nation in general. [2] Here, we will discuss the different factors which helps in prediction the stock values.

### 1.2.1 Earning Per Share :

EPS is the main factor that affects the stock price of a company. It tells about the company's credibility and public's confidence. It is basically a ratio of the total income of company and the outstanding shares that are not yet sold.

$$EPS = \frac{NetIncomeDividends}{AverageOutstandingShares} \quad (1.1)$$

### 1.2.2 Price Earning Ratio :

Present price of share of a company is estimated by this. [3] It is the ratio of market value of each share and EPS. Higher value of price earning ratio indicates positive growth of company's finance. Lower value of this ratio indicates that the rates are going down and it is a good time to buy stocks.

### 1.2.3 Earning Per Share :

Dividends are the profit which a company makes and distributes it to its shareholders. The price dividend ratio gives information about the stability

of company in the market which in turn indicates investors whether to invest in a particular company or not. Even if the price of stock do not increase, increase in dividend indicates that the company is at profit and ensures public confidence in the company.

A summarized table from has been provided to give an idea of how all of these indicators are related.1.1.1.

| Formula List         |  |
|----------------------|--|
| Indicators           | Formulae   |
| Earning Per Share    | $\frac{\text{Net Income} - \text{Dividends}}{\text{Average Outstanding Shares}}$ |
| Price Earning Ratio  | $\frac{\text{Market Value per Share}}{\text{EPS}}$                               |
| Price Dividend Ratio | $\frac{\text{Price per stock}}{\text{Dividend}}$                                 |

Table 1.1: Table showing formulae of Indicators

## 1.3 Trading Strategies

This section describes the optimal financial strategies followed my buyers and sellers to maximize profit.

### 1.3.1 Buy and Hold(BH) :

This strategy is based on static investments. In this the buyer buy stocks for a long period of time for example one year and play safe. The amount of profit is not too high and so does the risk factor. This strategy refrain from dynamically buying and selling stocks.

### 1.3.2 Stop and Objective(S0) :

In this strategy the investors carefully analyzes the market with the help of aforementioned market indicators and try to maximize profit. They dynami-

cally buy and sell stock after thoroughly analyzing the market and making an optimal decision.

### **1.3.3 Neural Network based Buy and Hold(NN-BH) :**

This concept of this strategy is pretty much same as the buy and hold strategy. The difference however is that the neural network takes the decision as to which stock has to be bought by analyzing the previous trends and price in the temporal domain.

### **1.3.4 Neural Network based Stop and Objective(NN-SO):**

This concept of this strategy is pretty much same as the stop and objective strategy. The difference however is that the multilayer back-propagated artificial neural network takes the decision as to when and which stock has to be dynamically bought and sold. This helps in maximizing profit for the investors.

## **1.4 The proposed method**

The methodology that is proposed is using multilayer feed forward back propagated artificial neural network with optimal structure to predict stock value. Although neural networks are widely used in different domains including stock market regression analysis, the following study presents the optimal architecture to obtain better results.

The study suggests the optimal number of hidden layers, epochs and number of neurons in each hidden layers to be used so as to obtain the best possible prediction result.

## Chapter 2

# Literature Survey and Previous techniques

### 2.1 Time Series Forecasting

Time series forecasting is the method using which we analyse the data in the past using the time series and predict the future values taking into consideration the effects of temporal domain. [4].

Various models of TSF are there like Auto-regressive Moving Averagefigure 2.1, Auto-regressive Integrated Moving Average, Generalized Auto-regressive Conditional Heteroskedasticity model and Kalman Filters.

### 2.2 Artificial Neural Network

Just like human brain, ANN is highly complex and highly parallel made up of simple processing units i.e., neurons. With the advancement in technology, ANN have a lot of applications. It basically acts a machine which stores and process past data to find correlation and then predicts the future values. [5] It typically consists of three layers i.e., input, output and a hidden layer. Although neural networks have been used to predict stock values, this study has given an optimal architecture which improves the efficiency of the model.

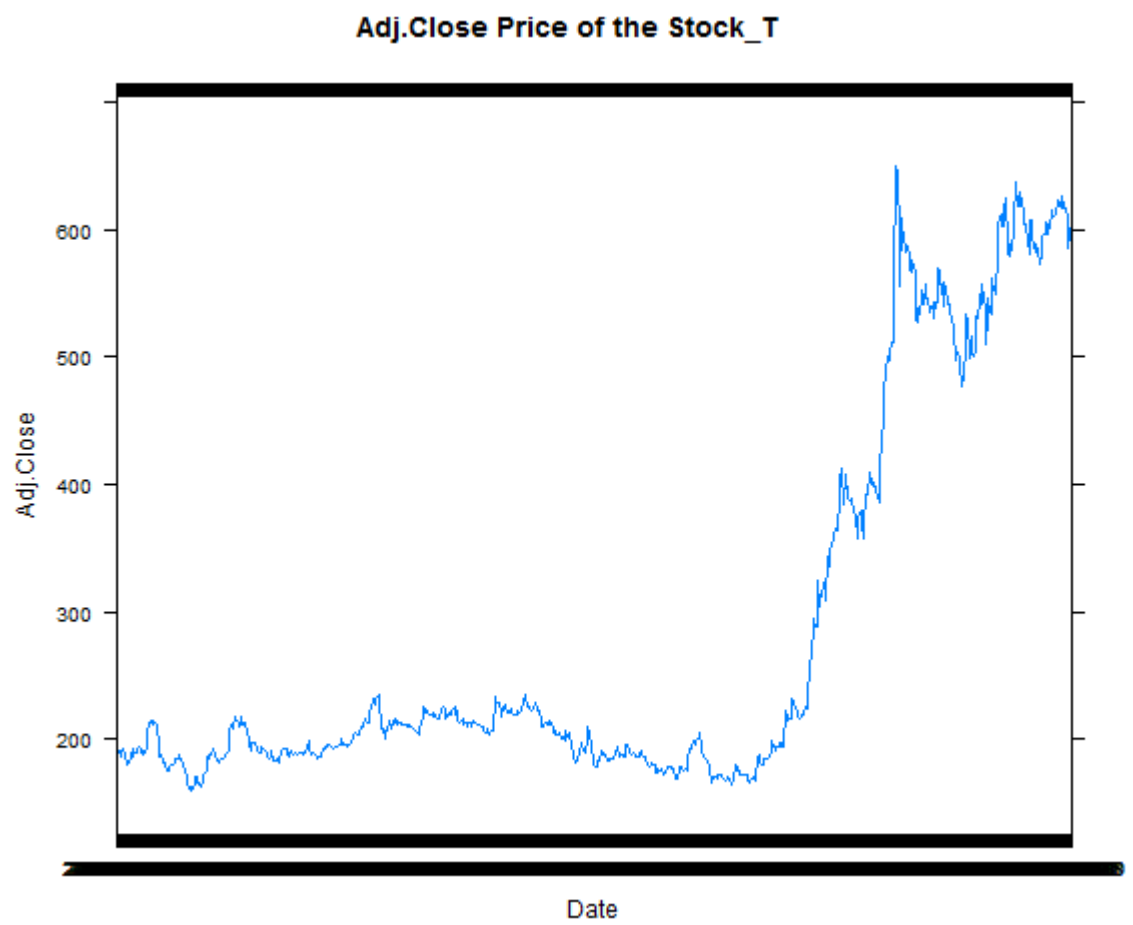


Figure 2.1: ARMA Stock Forecasting

## Chapter 3

# Advantages of proposed method over traditional methods

Traditional methods like time series forecasting uses function approximations and they do not go along well when the input factors become highly stochastic in temporal domain. The obtained results are not very accurate and hence we use artificial neural networks.

The first advantage of the proposed method over the traditional methods is that it is accurate and its modelling can be change depending on the input factors. The architecture is flexible and learning takes the stochastic input factors well by extrapolating the present values to the future values. The number of epochs, hidden layers and number of neurons can be changed and tested to come up with an optimal architecture for improved accuracy.

The given method outstrips the traditional time series analysis [5]. The major difference between the two methods stem from the way both methods work, traditional methods like auto regressive moving average and auto regressive integrated moving average have difficulty analyzing the dynamic data and the stock data is highly dynamic in nature. Neural networks on the other hand works comparatively well with dynamic data to accurately predict the future values.

# Chapter 4

## Methodology

### 4.1 Artificial Neural Network

This section gives an in depth knowledge about the working of artificial neural network. figure 4.1 The model used in this study which gives the best result consists of one input, an output and two hidden layers. For this particular problem statement of stock value forecast, two is the optimal number of hidden layers as they improved the accuracy and efficiency of the model without compromising the time complexity [6]. This study has considered a maximum of 5000 epochs.

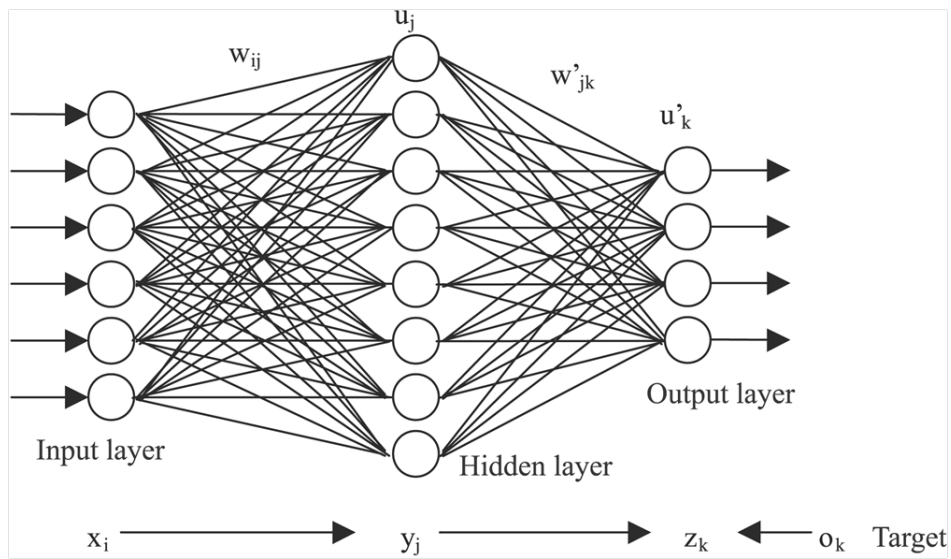


Figure 4.1: Artificial Neural Network



The different layers of ANN are as follows:

1. **Input layer :** The input is fed in this layer. In this case the company's stock prices on the daily basis considered for 44 days. The financial data are taken from reliable sources like Yahoo.
2. **Hidden layer :** Different number of hidden layers were tried with varying number of neurons in each layer and it was found that optimal results were obtained if the number of hidden layers were restricted to 2 and first hidden layers consists half the number of neurons present in input layer and second hidden layer contains one tenth of the number of neurons in the first layer.
3. **Output layer :** This layer provides the final result calculated by the hidden layers which is tested with the actual values to obtain the accuracy of the model. If the error is high, it is back propagated so that the ANN can learn and synaptic weights can be changed to decrease the error.

## 4.2 ANN Training

For forecasting purpose, the ANN should be trained first so that the synaptic weights can be changed to their accurate values [7]. Back propagation of error is used to train the model [8]. The synaptic weights are changed accordingly so that the percentage error is decreased. The stock price are obtained from yahoo [9]. These values are fed to the input layer to train the model. The error is calculated by taking the difference between the actual value and the value predicted by ANN and in this way the motive becomes to minimize the error to increase the accuracy and change the input synaptic weights accordingly.

### **4.3 Bias arrangement and synaptic weights**

The synaptic weights initial values were set between 0 and 1  $[0,1]$ . The bias is one for the two hidden layers that have been used in this model. The initialization of weights is arbitrary in nature but as the learning starts, the weights are adjusted automatically to give higher accuracy. The model should be such that the learning does not become stagnant in initial stages and it should improve continuously till higher ranges.

### **4.4 Binary classification for stock analysis**

The ANN is trained using the financial data obtained from the training set. After the training phase, extensive testing is done to be sure about the accuracy of suggested model so that the model can be used in practical applications. Testing is done by comparing the predicted and actual stock values. If the mean of predicted data is more than that of training data set then the user should buy the stock according to the system and vice versa. In this way the model also act as a binary classifier as to whether to or not to buy the stocks.

## Chapter 5

# Results of the proposed method

The predicted results obtained by the suggested architecture is checked against the actual values of stock to predict the accuracy of the model. The market open and close values were taken into consideration.

Data input sequence was set to be 44 i.e., 44 days data was taken into account and were fed to the input layer of the ANN. After empirically testing the various values the optimal architecture of ANN was chosen based on the accuracy of the model. The results show that the accuracy is high if the number of neurons in first hidden layer is half the number of input neurons.

figure 5.1 show the learning when less number of neurons are taken with high number of epochs i.e., 5000. It has been seen that high number of epochs gives improved results but it takes a comparatively longer time for the ANN to learn. Hence, the optimal number of epochs were set to 5000.

It has been seen that the learning is drastically improved and actual values are very close to the predicted values if the number of neurons in the hidden layers are  $m/10$  and  $m/2$  where  $m$  is the number of neurons in the input layer. figure 5.2 show the learning when we have an optimal neural network architecture proposed by this study.

Hence, the optimal neural network architecture proposed is:  $[m - m/2 - m/10 - 1]$ , where  $m$  is the number of neurons in each input layer.

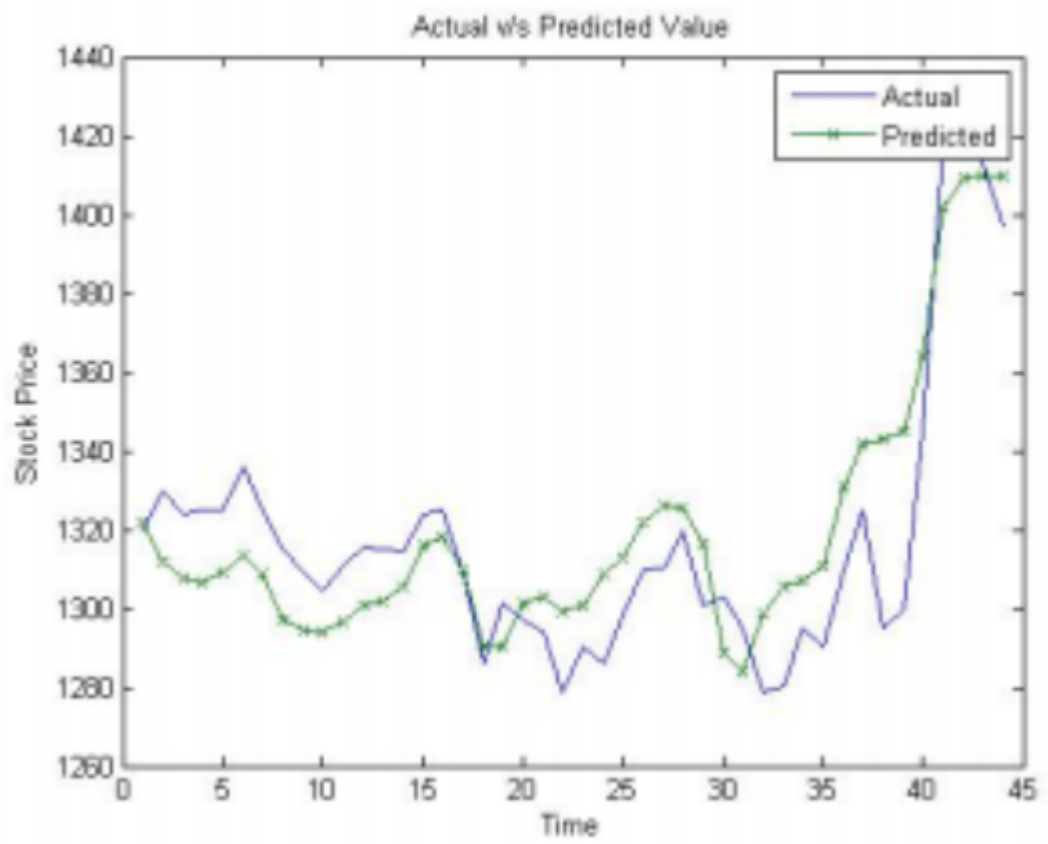


Figure 5.1: Less number of neurons in hidden layer with 5000 epochs

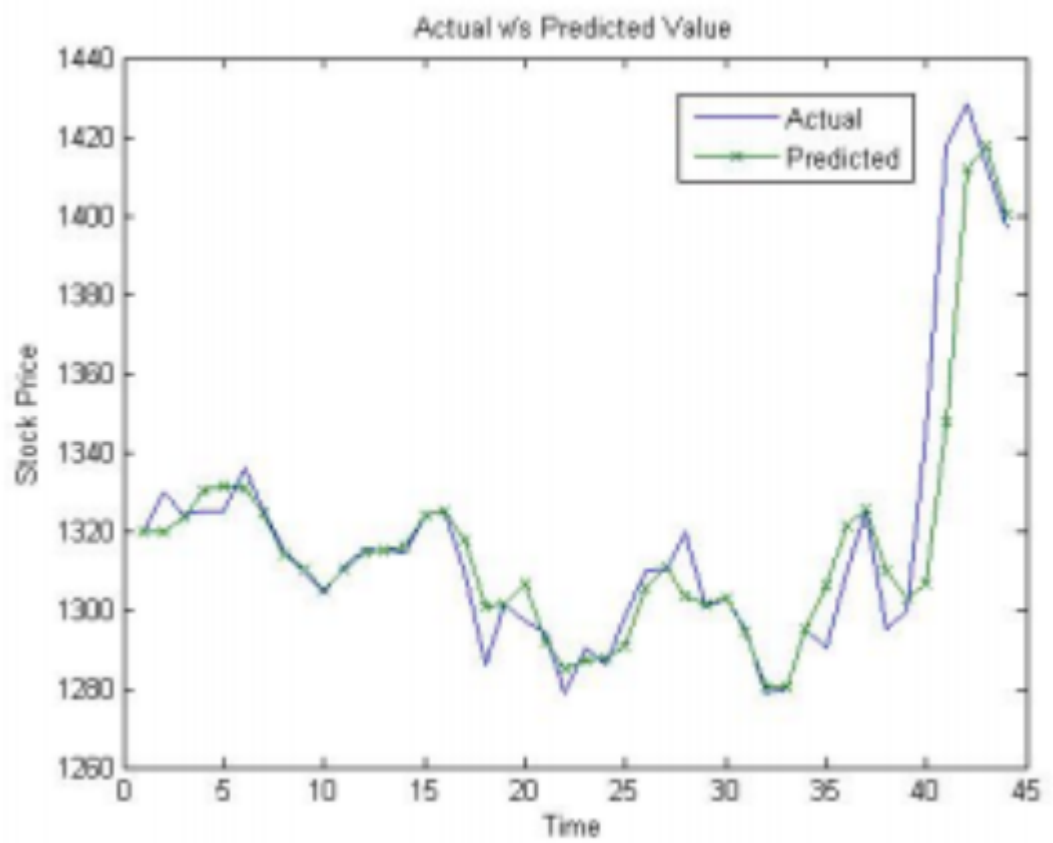


Figure 5.2: More number of neurons in hidden layer with 5000 epochs

# Chapter 6

## Conclusion and Future Works

Artificial neural networks are being widely used nowadays for various classification and regression analysis. This study shows the power and usage of artificial neural networks in the financial market to predict stock price. An optimal neural network architecture is of supreme importance in these kind of problems, so that the model learns faster, is efficient and accurately predict the results. This study has proposed an optimum architecture based on empirical observation. The general form of architecture is  $[m \ m/2 \ m/10 \ 1]$ , where  $m$  is the number of neurons in each layer and number of hidden layers are 2.

Further studies in the area of market and stock forecasting [10] uses ANN with varied architecture to predict stock values more accurately. So, this study provides a measure to select the optimized parameters in terms of neurons and epochs so that an accurate forecasting can be provided. This methodology can be used by market enthusiasts to further study and predict the trend in share market. In future, more data in temporal domain can be fed to ANN with the proposed architecture and see the results. The accuracy of stock market analysis is still not very high as it depends upon many stochastic factors but carefully enhancing the model in future based on more data and taking into consideration more varied factors can increase the percentage accuracy and can be used to remove uncertainty in the stock market.

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# Appendices

## Appendix A

Base paper used for preparation  
of seminar report and  
plagiarism report.