Performance Analysis On Metaheuristic Based Hybrid Neural Network To Predict The Stock Movement

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Abstract:Stock market prediction is a time series forecasting problem. For an efficient stock price prediction, in this paper optimization based neural network learning scheme has been developed that alleviates the existing Artificial Neural Network (ANN) limitations such as local minima and convergence issues. The existing gradient descent based algorithms are local search algorithms. To find global optimum solution, Metaheuristic based Hybrid Neural Network (HMNN) has been developed. The hybrid neural network executes optimization of activation nodes, optimization of weights and learning parameters. To illustrate this, we apply the proposed HMNN method to study the movement of closing prices of stock market. The algorithm has been practically examined for performance in terms of Mean Absolute Percentage Error, accuracy, precision, recall, completeness, F-measure where it has performed better as compared to major existing schemes. The proposed scheme exhibited 94.97% prediction accuracy while guarantee optimal precision, F-measure and recall.

Index Terms:Stock market, machine learning, artificial neural network, HMNN, metaheuristics,Optimization

1 INTRODUCTION

Share markets are places where stocks, commodities, financial securities, etc. are traded each second. Financially, Share markets are extremely pivotal in the economic growth of the country. Thus, nature of share markets represents the economic future of the country. Inferable from this reality, the forecasting of share markets is very essential for the speculators as well as for all the other stake holders. Stock market prediction is a remarkable topic and extremely challenging financial time series forecasting problem. Time series data is a sequence of observations of the defined variable at a uniform interval over a period of time in successive order [1]. Stock prices affected by many factors. The volatile nature of the stock market makes it difficult to apply simple time-series or regression techniques [2]. There are various standard statistical models dealing with non-stationary time series and having unsatisfactory forecasting performance. Machine learning method proposed in recent years performs better than the statistical methods. Artificial Neural Network (ANN) is one of the popular machine learning methods used to predict future trends [3]. Neural network consists of neurons arranged in different layers and connections (weights) are established between them as shown in figure1. Neural network can be a universal function approximator, capable of forecasting any non linear data. The performance of neural network greatly effect on some components such as network structure, number of neurons and arrangement of neurons. In fact, ANN has been employed in numerous utilities, but still it possesses certain limitations in terms of slow learning ability, local minima etc and hence require further optimization to achieve certain optimal performance.

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Neural network optimization is met by searching an appropriate network structure and the weights. Finding network structure includes determination of appropriate neurons (i.e. activation functions), number of neurons, and arrangement of neurons. Finding appropriate weights indicates the Optimization weight vector of a neural network. Metaheuristic algorithms are instantly turning into the exceptional systems for highly challenging for optimization problem [4]. The metaheuristic based neural network optimization ensures error minimization in stock market forecasting problem.

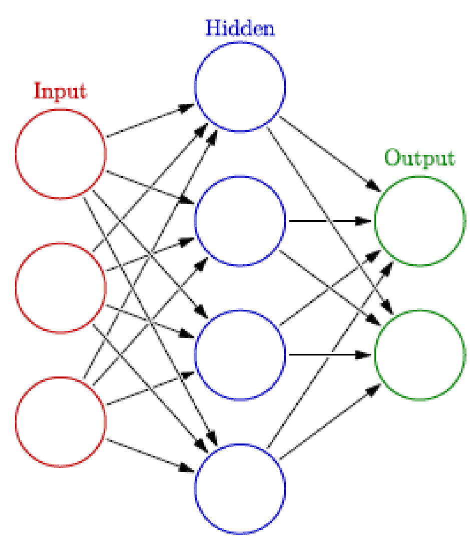


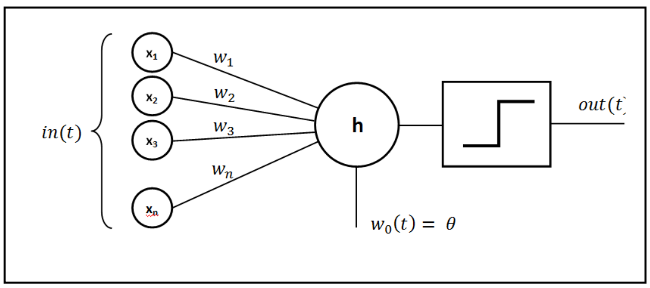
Figure 1: Neural Network

The objective of this work was to propose a novel Metaheuristic based Hybrid Neural Network (HMNN) for speculative performance in stock market forecasting. HMNN system employs optimization for input layer, weights and nodes so as to enhance learning efficiency of the ANN. In this paper, the performance measures MAPE, precision, recall have been employed and the respective performance has been analyzed using confusion matrix. The remaining sections discusses, related work in Section II, which has been followed by proposed research discussion in Section III. Section IV presents the results and analysis and conclusion has been discussed in Section V.

2 Related Works

2.1 Artificial Neural Networks

ANN is a mathematical model capable of processing information. Neural network posses attributes of learning, generating, parallel processing and error endurance, which make them powerful in solving complex problems [5]. ANN is used to train the prediction model to identify the trend from the given data. ANN consists of components such as layers, weights and nodes. The layers are input layer, hidden layer and output layer. Each node in one layer connected with another node in another layer with some weight. The model is activated by supplying input and Activation functions are used in both hidden layer and output layer. The input value is fed into the input layer.



The output of input layer is connected to the hidden layer followed by output layer. The above figure shows the information processing of a simple node. The summation function 'h' to the hidden layer node is represented as

$$h = \sum_{i=0}^{n} w_i x_i$$

$$w_i = weight\ of\ the\ input$$

$$x_i = input\ value$$

The output is generated by supplying the summation function h to activation function in output layer. The optimization of neural network indicates the arrangements of nodes, appropriate activation function at nodes, number of layers and connection weights.

2.2 Optimization of Neural Network

Neural Network commonly takes much time for learning process to obtain best weights [6]. FNN optimization is to minimize the cost function by searching optimum weights. It includes finding activation function, training environment and optimum architecture. The components are optimized separately one-by-one. Firstly optimizing weights by keeping architecture fixed. Optimization of architecture is achieved by weights fixed and optimization of activation function achieved by both architecture and weights fixed. Therefore the components are optimized simultaneously. To optimize the components using metaheuristic all components are to be represented into a vector form.

2.3 Metaheuristic Approach

Metaheuristic methods are aimed at finding a solution that is "good enough" in a computing time that is "small enough", therefore providing a better trade-off between solution quality (i.e. accuracy) and computing time [7]. Metaheuristic approach is alternative model to optimize neural network. This approach uses nature inspired techniques to optimize the neural network to overcome the problem with the conventional approach. Metaheustic algorithms are categorized as shown in the Figure 3. All tables and figures will be processed as images. You need to embed the images in the paper itself. Please don't send the images as separate files.

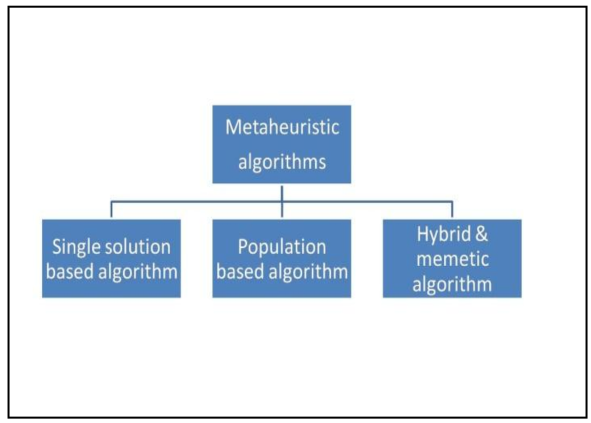


Figure 3: Categories of algorithms

3 PROPOSED SYSTEM

This section discusses the proposed Metaheuristic based Hybrid Neural Network (HMNN) for stock market prediction. HMNN: Metaheuristic based Hybrid Neural Network for stock market Prediction. Metaheuristic are non-deterministic in nature hence they offer near optimal solution. Metaheuristic are efficient in solving more complex optimization problems. FNN optimization aims to optimize the weights. Optimization of weights itself includes minimization of cost function.

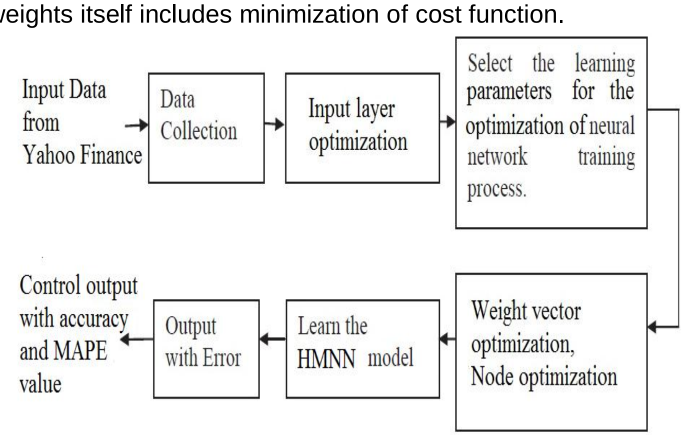


Figure 4: Proposed HMNN model

Hence the optimization of FNN depends on the optimization of weights along with finding optimum activation functions, parameters of learning algorithm.
Implementation of Proposed Algorithm:

Step 1:
Learning Rate, η(0.001)
Number of Data items, Size of data
Number of hidden layers, nH
Number of nodes in each layer, n
Weights W_i, i=1,2,3..
Activation Function (sigmoid)
Step 2: input layer optimization
 i) Pre processing of input data for feature extraction
 ii) Clustering on feature vector.
Step 3: Define weights into vector called weight vector.
Step 4:
 i) Define the attractiveness and brightness.
 ii) Calculate the attractiveness of weight vector
Step 5: Activate the nodes with appropriate activation function
Step 6: Ensemble of all steps gives the predicted value
Step 7: Analyzing the performance using MAPE, accuracy factors

1. Optimization of input layer

Input layer optimization uses dimensionality reduction techniques for feature reduction. Optimization of training data can be considered as input layer optimization. A subset of input features fed to the input layer rather than supplying the whole set of input features. Many dimensionality reduction methods have been proposed, a very famous one is principal component analysis (PCA), which assumes linearity of the manifold [8]. The input space is divided into number of regions and the sparse region of the input data is generated by using k-nearest neighbour clustering method [9]. This algorithm searches for the n-dimensional pattern space of the training data, and finds the k training samples closest to the sample to be sorted by a certain distance measure, and finally the category is judged to be the class that has the most nearest neighbours of k-nearest neighbour [9]. The work carried out by pre processing of data done followed by clustering.

1. Optimization of weights

The success of neural network depends on the training algorithm. The training algorithm finds the optimal set of weights. The Firefly algorithm (FA) [10] is a swarm intelligence metaheuristic optimization method is introduced to do carry out this task. In metaheuristic model the weights are mapped into a vector form called weight vector w having n-dimension. Here 'n' represents the number of weights in the network. The appropriate operators in the algorithm are used to update the weights and error is used as fitness measure for selection of weights.Firefly algorithm [10] is designed based on the flashing characteristics of flies. Those are 1. All fireflies are unisex so that one firefly will be attracted to other fireflies regardless of their sex [10]. 2. Attractiveness is proportional to firefly brightness. For any couple of flashing fireflies, the less bright one will move towards the brighter one. The brightness decreases when the distance between fireflies is increased. The brightest firefly moves randomly, because there is no other bug to attract it [10]. 3. The brightness of a firefly is affected or determined by the landscape of the objective function to be optimized [10]. The attractiveness function of the firefly is established by:
$\beta(r) = \beta_0 . e^{-\gamma r^2}$ Where β_0 is the firefly attractiveness value at $r = 0$ and γ is the media light absorption coefficient.

1. Optimization of nodes

Node optimization is achieved by choosing appropriate activation function at the nodes of neural network. Easier optimization, fast convergence, and high computation speed in deep networks are the main advantages of the Rectified Linear Unit [11]. Neural network shows better performance when using different activation function at different node. The suitable activation function is determined by the relationship between input and output. In this study different activation functions were adopted namely linear function, log-sigmoid function and tangent sigmoid function Linear function: The following equation represent the linear transfer function:
$l(x) = x$ Log-sigmoid function: The function in the range (0,1) is sigmoid function. The representation of the function is: $s(x) = \frac{1}{1+e^{-x}}$ Tangent sigmoid: The function defined in the range (-1,1) is called tangent sigmoid. This is represented as: $t(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}$ A single or combination of these functions will result in better approximation of given problem.

4 RESULTS AND DISCUSSION

This section discusses the research variables, results obtained and respective performance analysis

Data Collection

Dataset is taken for three different sectors namely Banking, IT sector and Automobile. Here we can get stock historical stock data and obtain the related parameters. The basic information of these data is as shown in "Table 1". The study is on day wise closing price of stock value. We collected the closing data from Yahoo finance[12]. The stock data of three companies Infosys Ltd, Vijaya Bank and Bajaj Auto is collected from 1st March, 2014 to 31st December 2017.

Evaluation Criteria

MAPE: The performance metric used is the Mean Absolute Percentage Error (MAPE).

$$MAPE = \frac{\sum |Predicted\ value - original\ value|}{number\ of\ points\ in\ test\ series}$$

RMSE: MSE/RMSE explicitly shows the deviation of the prediction for continuous variables from the actual dataset.

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{j=1}^{n}(y_j - \hat{y}_j)^2}$$

It measures the average magnitude of the error and ranges from 0 to infinity.

Index	Description
open	price at the beginning of time
close	price at the end of time
low	minimum price
high	highest price
volume	number of stock transaction
Adjusted close	stock's **closing** price considering distributions and corporate actions

Table 1: Description of stock data

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Construct	Mathematical Expression
Recall	TP/(TP+FN)
Precision	TP/(TP+FP)
Specification	TN/(TN+FP)
F-measure	Recall*precision/ Recall+precision
Accuracy	(TN+TP)/(TN+FN+FP+TP)

Table 2: Measures

COMPANY	MAPE
INFOSYS	18.33
VIJAYA BANK	15.24
BAJAJ AUTO	16.28

In Table 2, various measures and constructs taken for performance. In this study we have considered stock data and fed to ARIMA model, neural network and proposed HMNN model. The results obtained are tabulated. The MAPE performance indicator is compared.

Table 3: Performance of ARIMA Model

COMPANY	MAPE
INFOSYS	6.5
VIJAYA BANK	6.3
BAJAJ AUTO	6.2

Table 4: Performance of Neural Network Model

Performance Analysis of Infosys Data				
Data Set Size	**No of Layers**	**NN Model**	**NNSVM Model**	**HMNN Model**
100	1	7.5	6.6	5.6
	2	7	6.5	5.3
	3	6.8	6.1	4.9
200	1	6.5	5.5	4.7
	2	6.3	5.1	4.3
	3	6	4.8	4.1
600	1	6.1	5.5	4.1
	2	5.9	5.4	3.8
	3	5.9	4.6	3.2

Table 5: MAPE indicator for Infosys Dataset

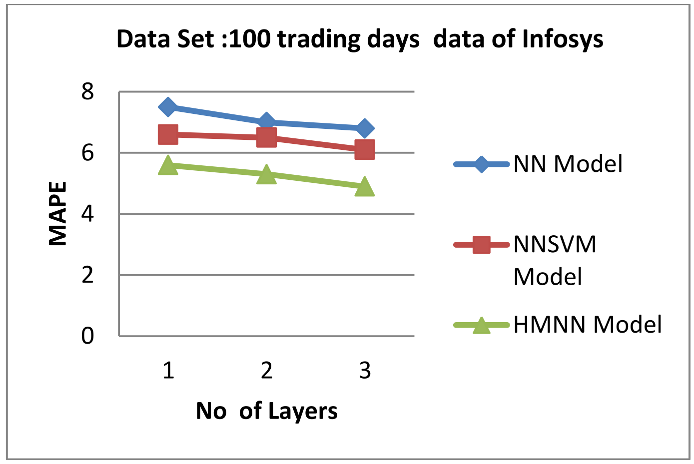


Figure 5: MAPE for 100 days data of Infosys

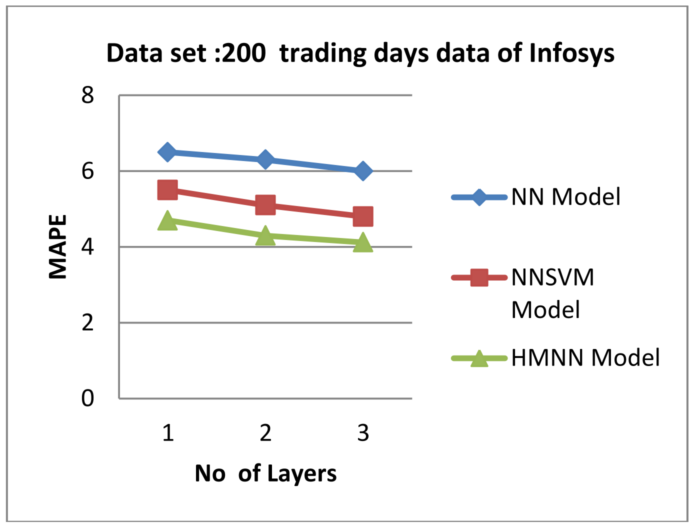


Figure 6: MAPE for 200 days data of Infosys

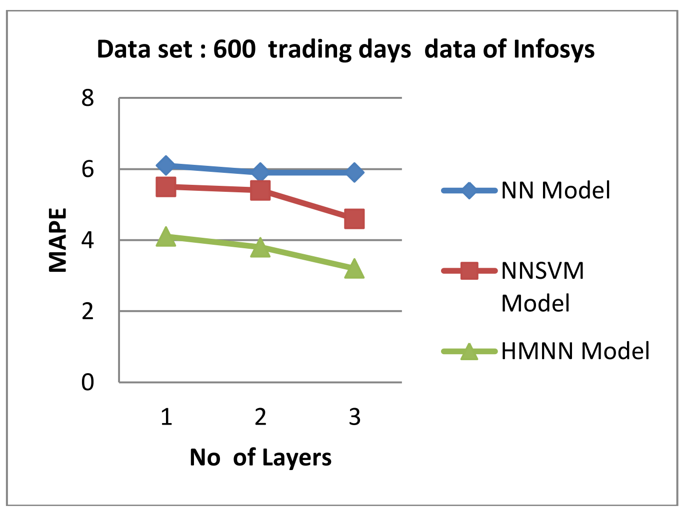
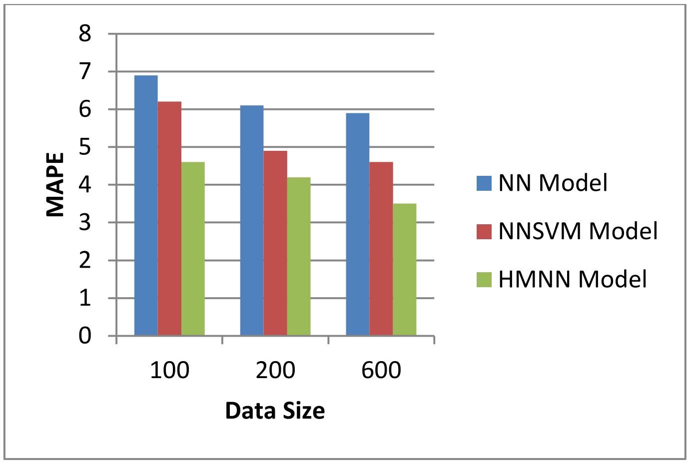


Figure 7: MAPE for 600 days of Infosys data



Performance Analysis of Vijaya bank Data				
Data Set *Figure 8: MAPE indicator for Infosys Dataset* Size	No of Layers	NN Model	NNSVM Model	HMNN Model
100	1	7.3	6.4	5.6
	2	7	6.2	5.4
	3	6.7	6	4.5
200	1	6.3	5.4	4.5
	2	6.3	5.2	4.3
	3	6.1	4.9	4.2
600	1	6	5.7	4.1
	2	5.9	5.3	3.7
	3	5.6	5.1	3.1

Table 6 : MAPE indicator for Vijaya Bank Dataset

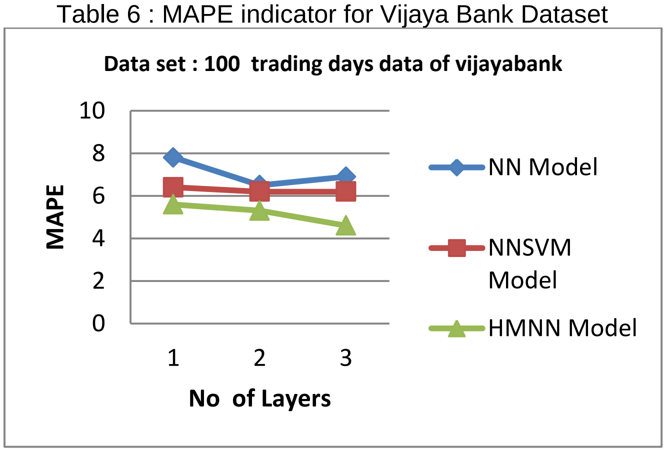


Figure 9: MAPE for 100 days data – Vijayabank

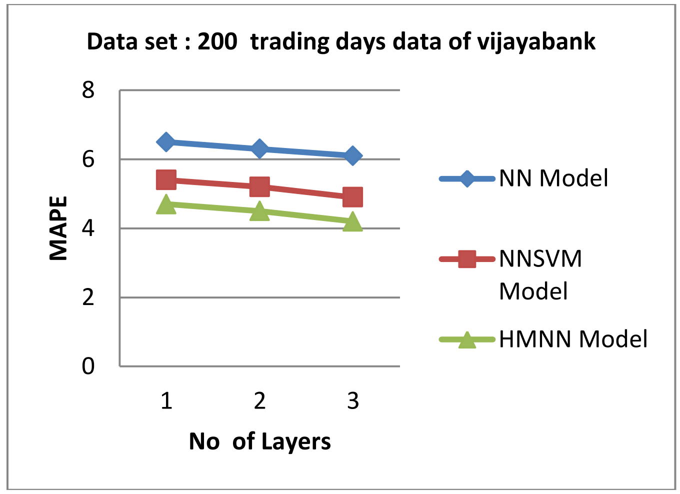


Figure 10: MAPE for 200 days data - Vijayabank

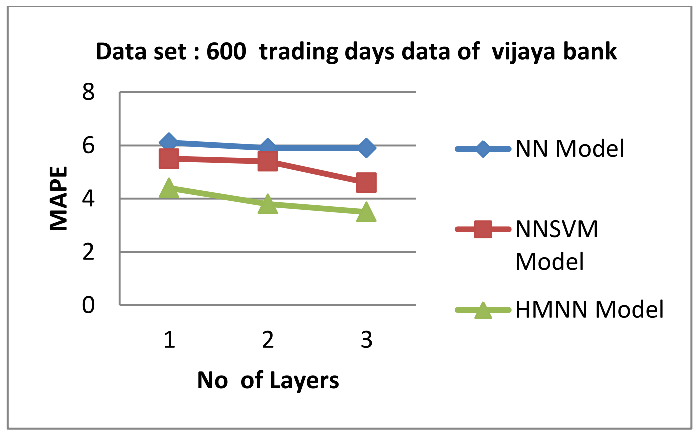


Figure 11: MAPE for 600 days data – Vijaya bank

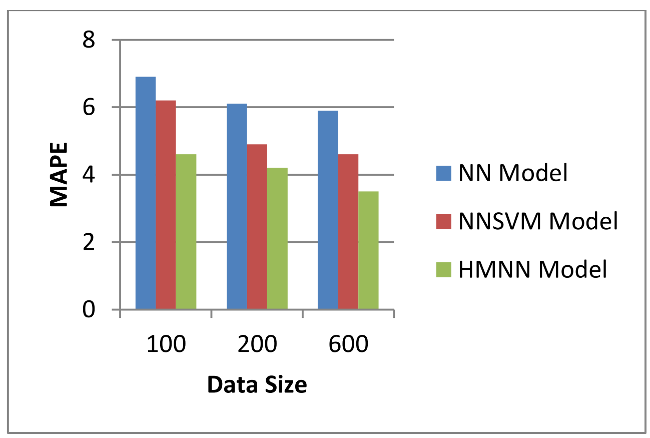


Figure 12 : MAPE indicator for Vijayabank Dataset

Performance Analysis of Bajaj Auto Data				
Data Set Size	No of Layers	NN Model	NNSVM Model	HMNN Model
100	1	7.8	6.4	5.6
	2	6.5	6.2	5.3
	3	6.9	6.2	4.6
200	1	6.5	5.4	4.7

	2	6.3	5.2	4.5
	3	6.1	4.9	4.2
600	1	6.1	5.5	4.4
	2	5.9	5.4	3.8
	3	5.9	4.6	3.5

Table 7: MAPE indicator for Bajaj Auto Dataset

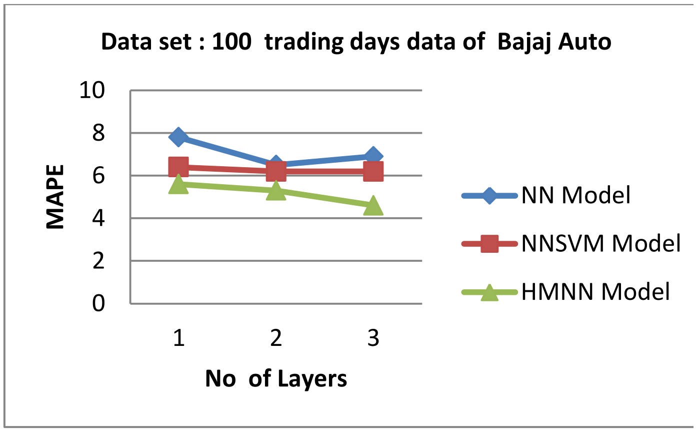


Figure 13: MAPE for 100 days data – Bajaj Auto

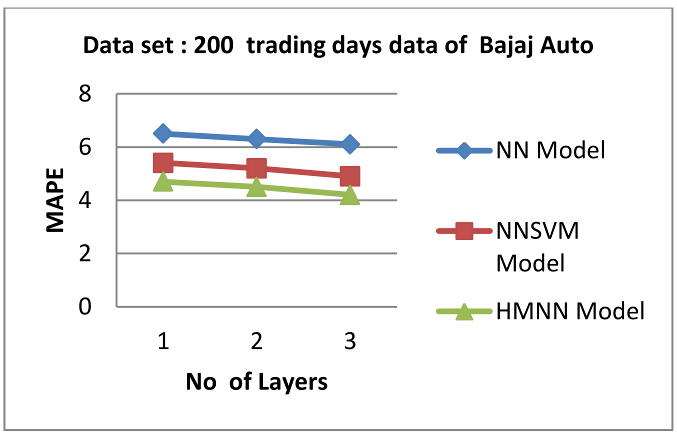


Figure 14: MAPE for 200 days data – Bajaj Auto

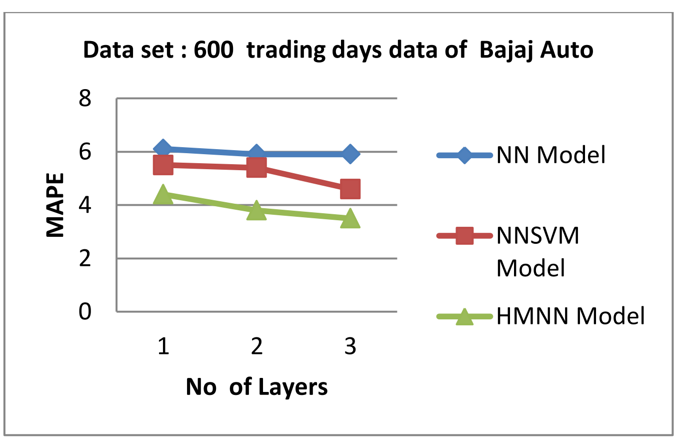


Figure 15: MAPE for 600 days data – Bajaj Auto

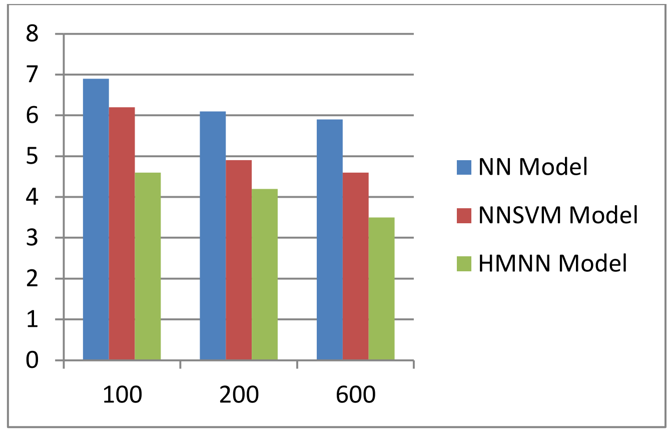


Figure 16 : MAPE indicator for Bajaj Dataset

CONCLUSION AND FUTURE SCOPE

The results indicate that the optimization of neural network has enhanced the performance. The three different sectors of data analyzed individually. The performance indicator MAPE shows a significant difference for different sizes of datasets as well as different types of data sets. The proposed method is compared with the previous methods. The proposed architecture of neural network has been tested with stock market data. The algorithm is showed a good efficiency to automatically anticipate the stock movement. The change in hidden layers and nodes in each layer provided the better results. This work can be extended with fuzzy logic mechanism for more efficient to predict the stock movement. In future the proposed method can be scaled to large datasets using fuzzy system.

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