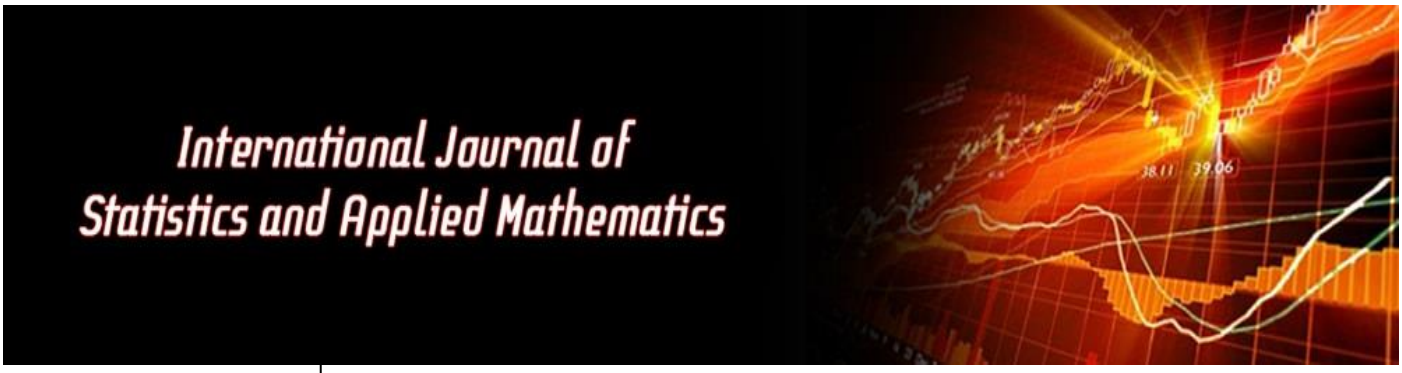

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BSE Sensex forecasting using a machine learning approach

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Abstract
Prediction of stock prices has played an important role in the financial decision-makers of investors. The BSE Sensex oscillates based on fewer influential factors with respect to time intervals and also financial parameters. Since the last decade's prediction of stock prices contributes to and challenging task to yield significant profit for companies. In this study, the Neural Network Auto-Regressive (NNAR) model has been used to predict BSE Sensex daily closing price data. Models were evaluated using performance measures like Mean Absolute Percentage Error (MAPE) and, Mean Square Error (MSE). The results showed that the NNAR(1-7-1) model gives more appropriate for model building with respective of a 91% of accuracy in predicting the stock prices in India.

Keywords: BSE Sensex, Neural Network Auto-Regressive (NNAR) Model, Price Data, Mean Absolute Percentage Error (MAPE), Mean Square Error (MSE)

Introduction
Recently Machine learning tools widely used in stock market trading, particularly in the share market. The share market indices are up and downs with respective time as well as financial factors. The Neural Network Model is used for the prediction of stock market trends. Many authors worked and predicted stock market prices using different kinds of time series approach like Auto-Regressive Integrated Moving Average (ARIMA), Artificial Neural Network (ANN) models, and Long Short-Term Memory (LSTM) models.

Moghar A and Hamiche M (2020) [1] developed a model using Recurrent Neural Network (RNN) and LSTM to predict the future stock market. They associated the accuracy of ARIMA and LSTM methods to forecast the time series data and the results showed that LSTM is greater efficient than ARIMA. Mehtab S, Sen J and Dutta A (2020) [2] explain an accurate model and designing of appropriate variables able to predict the stock prices and their movement patterns. Chan T, Sy A and Vc Y (2017) [4] have proved the ability of the Artificial Neural Network (ANN) method, an artificial intelligence system, in predicting the movement of the FTSE Bursa Malaysia. Chan T and Sy A (2015) [3] in their study also used two methods, namely ARIMA and ANN to predict Bursa Malaysia stock prices where their findings revealed that the ANN method outperformed the ARIMA. Abdu M S and Saratha S (2017) [5] have associated the multiple linear regression (MLR) method and ANN to predict the Malaysia stock exchange market and the result is the prediction model using ANN is more accurate than MLR. Phua PKH, Ming D, Lin W (2000) [9] were applied a neural network with a genetic algorithm to the stock exchange of Singapore to predict the market direction. Abhishek K, Khairwa A, Pratap T, Prakash S (2012) [10] used feed forward neural network architecture for stock market trend prediction.

The aim of the study is to daily closing prices of BSE Sensex over one period and develop a forecasting model for BSE Sensex closing prices using NNAR models, finally identifying the best-fitted model using the starting diagnostic techniques as well as sophisticated models and precision tools. It is believed the best model is probably to learn from the past pattern of the closing prices of BSE Sensex.

Methods and Materials

Most of the time series data is commonly used as forecasting models like linear and, nonlinear models. In this paper to study the data from the year May 2002 to May 2023 was used and around 248 data points were considered for forecasting the model for the Bombay Stock Exchange (BSE) Sensex closing data has been taken for modelling and forecasting the BSE Sensex in India. The Neural Network Auto-Regressive (NNAR) model is used and identifies the significant parameters. (p, k) model. The purpose of this study is to identify the best forecast NNAR (p, k) model for BSE Sensex using Machine learning approach methodology. The Statistical Software R-Language was used for the forecasting model building and residual error analysis.

Diagnostic analytics

A. Test for normality- Jarque bera test

One of the Normality tests was applied in the study of forecasting time series data. The Jarque-Bera test was used for the normality of the univariate time series data. The null hypothesis for this test is data follows normally distributed. The JB test is based on sample skewness and sample kurtosis of the values.

$$JB = \frac{n}{6}\left(S^2 + \frac{(K-3)^2}{4}\right)$$

Where S : Sample Skewness, K : Sample Kurtosis and n: Size of the sample.

B. Test for outlier-grubbs test

Grubb's test is used to detection of outliers in univariate time series data and assumed that there are no outliers in the time series data. The values of Xi follow normally distributed and the null hypothesis is an outlier is present.

$$G = \frac{Max|X_i - \bar{X}|}{s}$$

Where X_i is the actual data points

C. Test for stationarity-augmented dickey-fuller test

The stationarity of the time series data can be tested through Augmented Dickey–Fuller (ADF) test of the unit root test. One of the assumptions on time series is non-stationary. To make sure existence of stationary relationship, the following stationary test Augmented Dickey–Fuller test (ADF) tests are employed in the study.

$$\Delta\lambda_t = \alpha_0 + \alpha 2t + \sum_{i=1}^{k} \beta\Delta\lambda_{t-1}$$

Where λ_t denotes the monthly index of the individual stock at time t, β is the coefficient to be estimates, k is the number of lagged terms, t is the trend term, α_2 is the estimated coefficient for the trend, α_0 is the constant and ε is white noise.

Neural network autoregressive (NNAR) model

The Feed-forward neural networks consist of a mixed input layer and hidden layers, and an output layer. The data flow in the forward direction, in this model has no back propagation. Usually, used NNAR model for time series forecasting. In this study, Neural Network Auto-Regression as non-linear generalizations of Auto Regression model NNAR (p, k) is a feed-forward neural network with a single hidden layer where p-lagged variables are used as inputs it is similar to an AR(p) model and k is the number of hidden neurons

The NNAR model is a feed-forward neural network that includes a linear combination function and an activation function. The function is defined as.

$$net_j = \sum_i w_{ij} y_{ij}\ ,\ f(y) = \frac{1}{1+e^{-y}}$$

Model performance measures

A. Mean Absolute Percentage Error (MAPE)

Using MAPE only makes sense if the BSE closing price with which the forecast is to be compared has the average absolute percentage amount by which forecasts differ from outcomes, using residual analysis for model forecasting. For evaluating the performance of the forecasted model, MAPE has been applied, which is defined as

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n} \frac{|A_t - F_t|}{A_t} \times 100$$

Where, A_t is Actual data and F_t is Forecasted data with respective time period t

B. Root mean square error (RMSE)

For the performance of the forecasting model in predicting the BSE Sensex closing price, Root Mean Square Error (RMSE) are chosen, the following equation of RMSE is

$$\text{RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(Y_i - \hat{Y}_i\right)^2}$$

Where, Y_i is the actual data, $\hat{Y}_i$ is the Forecasted data with respect to time period i

Results and Discussion

Table 1: Descriptive Statistics of BSE Sensex daily closing price

Descriptive Statistics	
Mean	59027
Median	59723
Minimum	51360
Maximum	63284
Standard deviation	2750.4
C.V (%)	0.0465
Skewness	-0.9975
5% percentile	53023
95% percentile	62461

The mean and median of the BSE Sensex daily closing price are 59027 and 59723 respectively and the standard deviation is 2750.4, which shows the mean and median values are very close to others indicating the normality of the data.

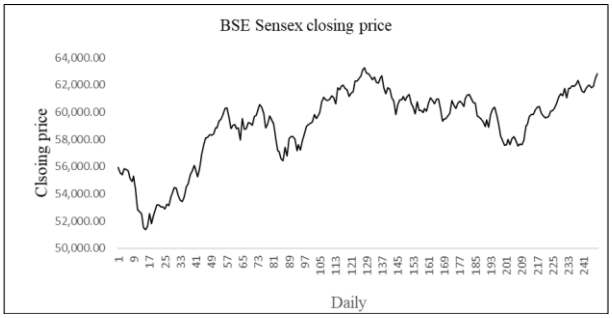

Fig 1: Actual trend of BSE Sensex closing price (30-05-2022 to 29-05-2023)

Table 2: Stationary test for BSE Sensex

Diagnostic test	Test value	p-value
ADF test - No Difference	-1.8002	0.6599
ADF test - First Difference	-6.1816	0.0100*
Normality test - Jarque Bera test	41.8210	0.0000**
Outliers – Grubbs test	2.7900	1.0000*

* Significant at 0.05 level and * * Significant at 0.01 level

Jarque Bera test used for normality of data, the test value is given by 41.821, which is significant at 0.01 levels, inferring that the BSE data follow normality and applied Grubbs test for outlier detection, which plays an important role in the prediction of the time series model. The test value is given by 2.7900, which is significant at 0.05 levels. It shows no outliers in the BSE Sensex price data.

Augmented Dickey-Fuller (ADF) unit root test has been used for data stationary. The null hypothesis is data was non-stationary. The absolute value of ADF is -1.8002, which is not significant at 0.05 level with no difference and it makes a significant first difference in the ADF test value if given by -6.1816, which is significant at 0.05 level therefore, the time series is stationary of the BSE sensex price values.

Table 3: Model performance measures

S No	NNAR model	RMSE	MAPE
1	NNAR (1-7-1)	458.55	0.6114
2	NNAR (1-5-1)	458.65	0.6114
3	NNAR (1-6-1)	458.65	0.6116
4	NNAR (1-8-1)	459.05	0.6124
5	NNAR (1-2-1)	460.02	0.6123

In this study, two feedforward neural networks are used. First NNAR model uses 1 lagged value and 1 node in the hidden layer. It has an average of 20 networks and each of which is a 1-7-1 network with 22 weights. It has been observed the accuracy of the models NNAR (1-7-1) the RMSE is 458.55 and MAPE is 0.6114 which is lower form other NNAR models, it shows it is an appropriate forecasting model for BSE Sensex daily closing price values. The rest of the NNAR models are explained very closely with respect to RMSE and MAPE values.

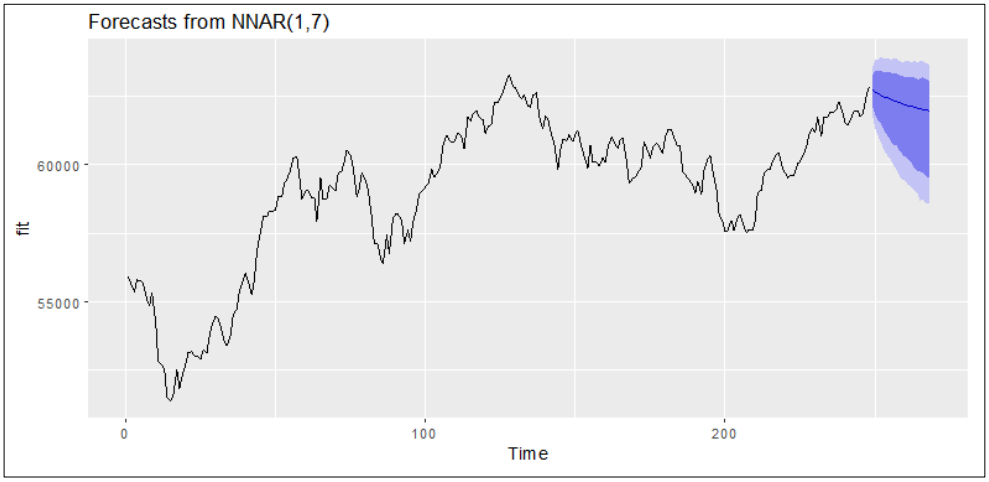

Fig 2: Forecast method NNAR (1-7-1)

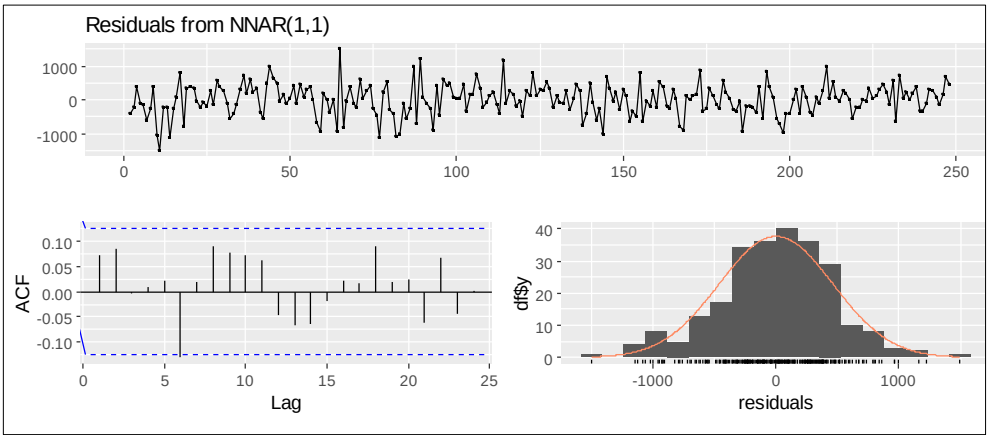

Fig 3: Residual for NNAR (1,1) model

Conclusions

In this paper, different Neural Network models are used to predict BSE closing prices from July 23 to June 24 and including a 95% confidence interval. These values represent the lowest and highest values of BSE prices, it is useful to locate the approximate closing prices. Among the two models, the model NNAR (1-7-1) has been the best performance in BSE Sensex closing prices. The NNAR (1-7-1) model generated more than 91% of accuracy and also gave good predicted values. In the future financial indicators can be included to increase the precision of the prediction models. These models suggested using sentiment analysis with the NNAR model to make a good prediction.

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