Various Stock Market Prediction Methods Using Data Science and Machine Learning

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Abstract

The Stock Market trends are highly volatile in nature. The recent studies have shown that news and sentiments also have an impact on stock prices. Even without it, it is difficult to accurately predict the prices and crisis. Therefore, we use data science, machine learning algorithms and statistics in order to do the huge calculations and make correct predictions. This review proposes a study of 5 such methods involving various algorithms and techniques for the prediction of stock market prices. The methods in this review contain the prediction techniques for predicting stock prices, crisis, and also the impact of news and social media sentiment on the stock price.

Keywords: Stock Market, Prediction, Algorithm.

1. Introduction

As we know, the stock market is highly volatile. So it's really hard to predict trends/crisis, such things in the case of stock market. But with the recent advancements in computing and analytics, we have found many ways and algorithms to help us with the task of the prediction of the stock market. This review aims to present 5 such methods developed recently that help us in the prediction of stock market trends. This review comprises of techniques to predict stock prices, crisis, anomalies, effects of news and sentiments on stock prices. This review presents various stock market prediction methods developed using machine learning algorithms and data science that give better predictions and lesser error than the traditional methods.

2. Overview

A. "A Hybrid Approach of Bayesian Structural Time Series With LSTM to Identify the Influence of News Sentiment on Short-Term Forecasting of Stock Price" [1]
This paper presents a method created by combining LSTM (Long Short Term Memory) with the BST (Bayesian Structural Time Series) in order to predict the stock price for short term. This method also takes news and social media sentiment into account while making the prediction.
This method gives significantly less error percentage than the traditional models like ARMA (Auto Regressive Moving Average), VAR (Vector Auto Regression), ARIMA (Auto Regressive Integrated Moving Average) etc. [1]

B. "Stock Trend Prediction Using Candlestick Charting and Ensemble Machine Learning Techniques With a Novelty Feature Engineering Scheme" [2]
This paper presents a method for deciding the investment strategy by combining the data collected from stock market, candle stick patterns, processing it with technical indicators and 8 triagram scheme using a neural network. This method works for prediction of stock prices. Also, this method uses multiple algorithms such as SVM (Support Vector Machine), LR (Linear Regression) etc. according to the situation so it gives better results than the traditional methods. [2]

C. "Novel Stock Crisis Prediction Technique—A Study on Indian Stock Market" [3]
This paper presents a method for prediction of stock market crisis by collecting the data from the National Stock Exchange (NSE) and then selecting features by using a hybrid feature selection algorithm that comprises of the RFE (Recursive Feature Elimination) and BFS (Boruta Feature Selection), an intersection of these two is performed and the final features are selected from the total 42 features. After this, the stock price bubble identification is done by using the RSI (Relative Strength Index) statistics. And finally, after all this data has

been collected, XGBoost (eXtreme Gradient Boosting) and DNN (Delayed Neural Network) Regression methods are used to predict stock crisis. [3]

D. "One Step Ahead: A Framework for Detecting Unexpected Incidents and Predicting the Stock Markets" [4]
This paper presents a method for prediction of stock prices by combining the news and sentiment data with the market data and predicting the behaviour of stock prices by using various machine learning algorithms like the decision tree, random forest etc. This method basically focuses on forecasting the stock prices around the days with news of terrorist attacks. [4]

E. "Forecasting Stock Market Indices Using Padding-Based Fourier Transform Denoising and Time Series Deep Learning Models" [5]
This paper presents a method for predicting the stock market prices by collecting the data from the stock market indices and the time series, denoising the data by using PFTD (Padding based Fourier Transform Denoising) method. Then the deep learning models are trained using methods like RNN (Recurrent Neural Network), LSTM (Long Short Term Memory), GRU (Gated Recurrent Unit). After this, the prediction is done. The prediction accuracy increases by more than 20% after applying the Padding based Fourier Transform.

3. Methodology

A. "A Hybrid Approach of Bayesian Structural Time Series With LSTM to Identify the Influence of News Sentiment on Short-Term Forecasting of Stock Price**"** [1]

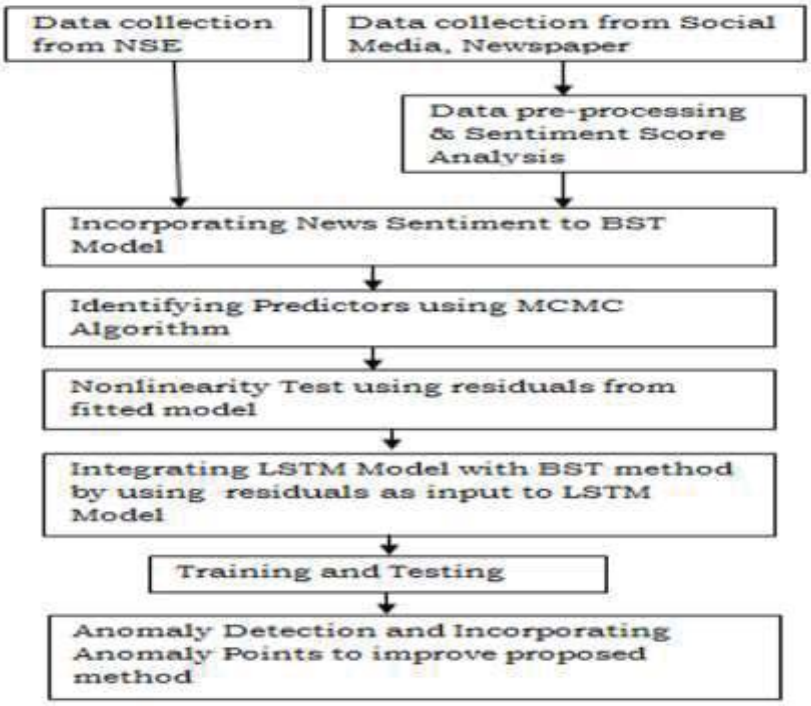


Figure 1. Proposed Workflow Model) [1]

The proposed workflow model of this method is shown in the above figure. The data is collected from the National Stock Exchange, news portals and social media. After this, the data pre-processing and sentiment score analysis is done on the data collected from the news portals and social media. After this, it is incorporated with the BST (Bayesian Structural Time Series). After this, predictors are identified using the MCMC (Markov Chain Monte Carlo) Algorithm. Then the non-linearity test is done from the fitted model. Then the LSTM (Long Short Term Memory) and BST (Bayesian Structural Time Series). Then the training and testing is performed. After this, the anomaly detection is done using the Isolation Forest (iTree) algorithm. This data is incorporated to improve the proposed method. [1]
Tools used: [1]

- R and Python [1]

- NLP and Stanford CoreNLP [1]
- SentiWordNet (It is a lexical resource used for identifying polarity of a statement (for example, polarity of a tweet). It can range from -1 to +1 indicating negative and positive polarities respectively.) [1]

- Slice Matrix-IO (used to detect the anomaly) [1]

Results: [1]

Mean Absolute Percentage Error(MAPE)	
Model	**MAPE**
ARIMA	14.97 %
VAR	14.30 %
Local Linear Trend Model without Sentiment Score (**Model-1**)	12.75 %
Local Linear Trend Model with Sentiment Score (**Model-2**)	10.8 %
Bayesian Nowcasting Model with Sentiment Score & Anomaly Points (**Model-3**)	**3.5 %**

Figure 2. Results of the proposed method [1]

As shown in the figure above, we can see that the Mean Absolute Percentage Error is really low compared to the traditional models ARIMA, VAR etc. The traditional models have this mean absolute percentage error around 13%, but the proposed model has only 3%, which is very less compared to that. Overall, this method is very efficient and a cut above the traditional methods.

B. "Stock Trend Prediction Using Candlestick Charting and Ensemble Machine Learning Techniques With a Novelty Feature Engineering Scheme**"** [2]
This paper presents a method for deciding the investment strategy by combining the data collected from stock market, candle stick patterns, processing it with technical indicators and 8 triagram scheme using a neural network. [2]

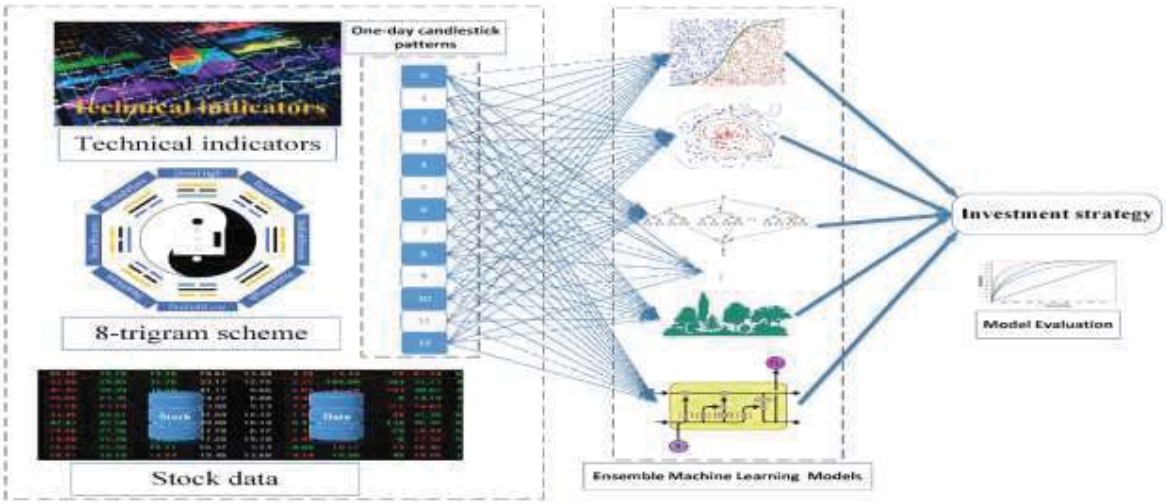


Figure 3. Proposed model [2]

The proposed model is as shown in the figure above. First, the data is collected from the stock market, the technical indicators are calculated, 8-trigram method is used to decide the price movements, then all this, combined with the candle stick patterns is given as an input for the proposed model. The model then decides which method to use and then gives an investment strategy. This method is really useful for stock price prediction.

Group of indicators	Technical indicators
Overlap indicators	Moving Average (MA), Exponential Moving Average (EMA), Double Exponential Moving Average (DEMA), Kaufman's Adaptative Moving Average (KAMA), Simple Moving Average (SMA), Parabolic SAR (SAR)
Momentum indicators	Average Directional Movement Index (ADX), Price Oscillator - Absolute (APO), Balance of Power (BOP), Commodity Channel Index (CCI), Moving Average Convergence/Divergence (MACD), Money Flow Index (MFI), Momentum (MOM), Relative Strength Index (RSI)
Volume indicators	Chaikin A/D Line (AD), Chaikin Oscillator (ADOSC), On Balance Volume (OBV)True Range (TRANGE), Average True Range (ATR), Normalized Average True Range (NATR)
Volatility indicators	

Figure 4. The Technical Indicators [2]

The above figure shows the Technical Indicators taken into account for the process. They are divided into four classes namely Overlap, Momentum, Volume and Volatility Indicators.

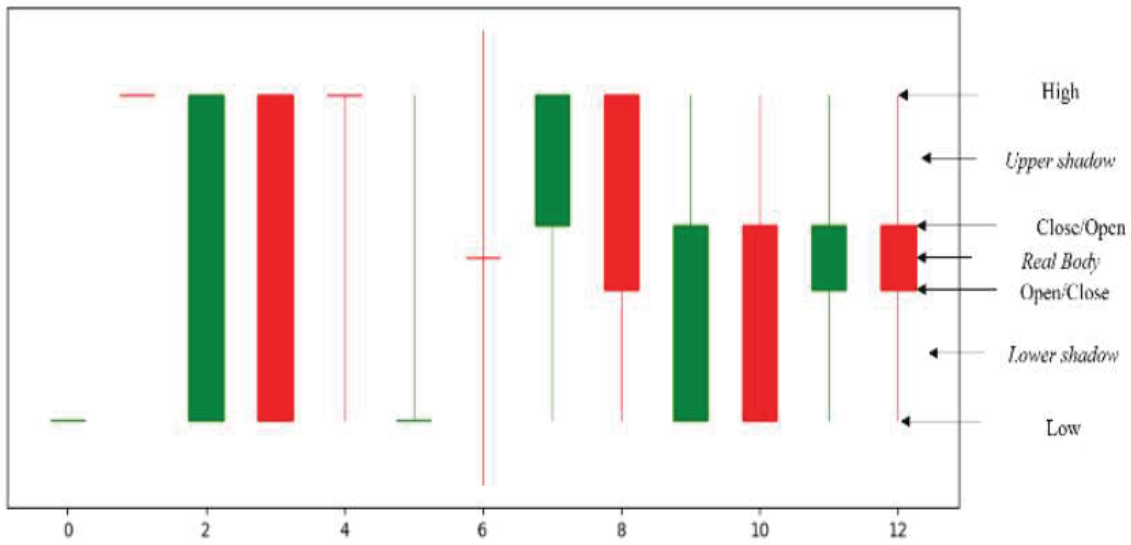
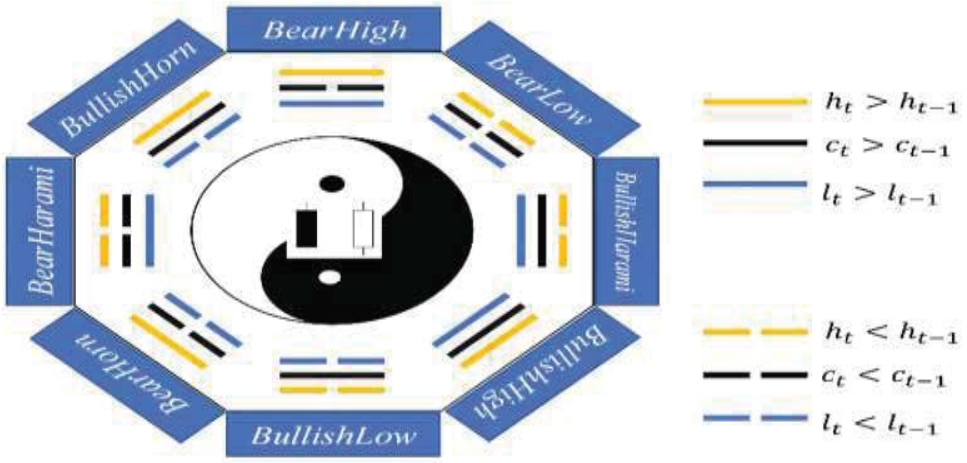


Figure 5. Sample of a Candle Stick Pattern [2]



Symbols	Description
h	h_t represents the highest price at time t, h_{t-1} represents the highest price at time t-1
c	c_t represents the closing price at time t, c_{t-1} represents the closing price at time t-1
l	l_t represents the lowest price at time t, l_{t-1} represents the lowest price at time t-1

Figure 6. The 8 Trigrams of Price Movements [2]

The above figure shows the 8-trigrams of price movements, along with its parameters and description of them.

Algorithm: Model Evaluation

Input: Patterns data which includes feature engineering data and different indicators

Output: *BestModel*, *F1 score*

```
0   Evaluation (features):
1     foreach p in patterns: Generate p_data of p;
2         LogisticRegression (p_data);
3         GridSearchCV of KNN (p_data);
4         GridSearchCV of SVM (p_data);
5         GridSearchCV of RF (p_data);
6         GridSearchCV of GBDT (p_data);
7         LSTM (p_data);
8         BestModel = MAX_F1 (LR, KNN, SVM, RF,
9   GBDT, LSTM);
        Save the best performance model BestModel,
    and F1 score for pattern p
    Output: List of best performance model, F1 score
    for each pattern
```

Figure 7. The Model Evaluation Algorithm [2]

The figure 7 shows the main model evaluation algorithm. The model evaluation algorithm decides which algorithm to use in order to predict the stock prices out of Logistic Regression, KNN (K-Nearest Neighbours), SVM (Support Vector Machine), Random Forest, GBDT (Gradient Boosted Decision Tress) and LSTM (Long Short Term Memory). This model gives the best model as output along with the F1 scores.

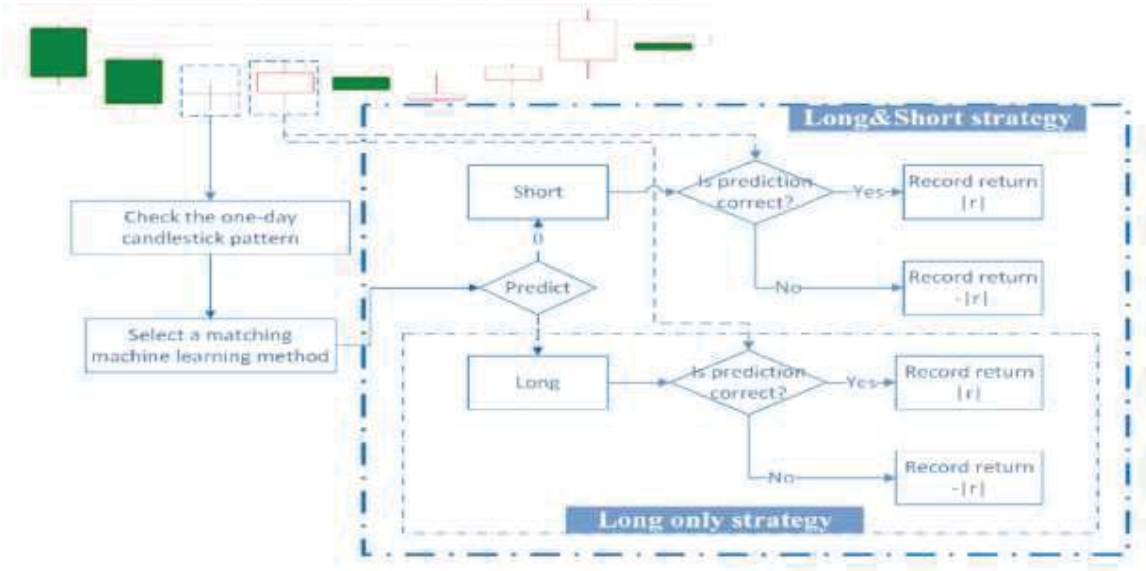


Figure 8. Prediction Flow Diagram [2]

The above figure shows the flow diagram of the proposed model. As we can see, the method has two parts, for the prediction of long and short term stock price respectively. Whether the predictions are correct or incorrect, the result is stored and incorporated in order to improve the existing model.

4. Results

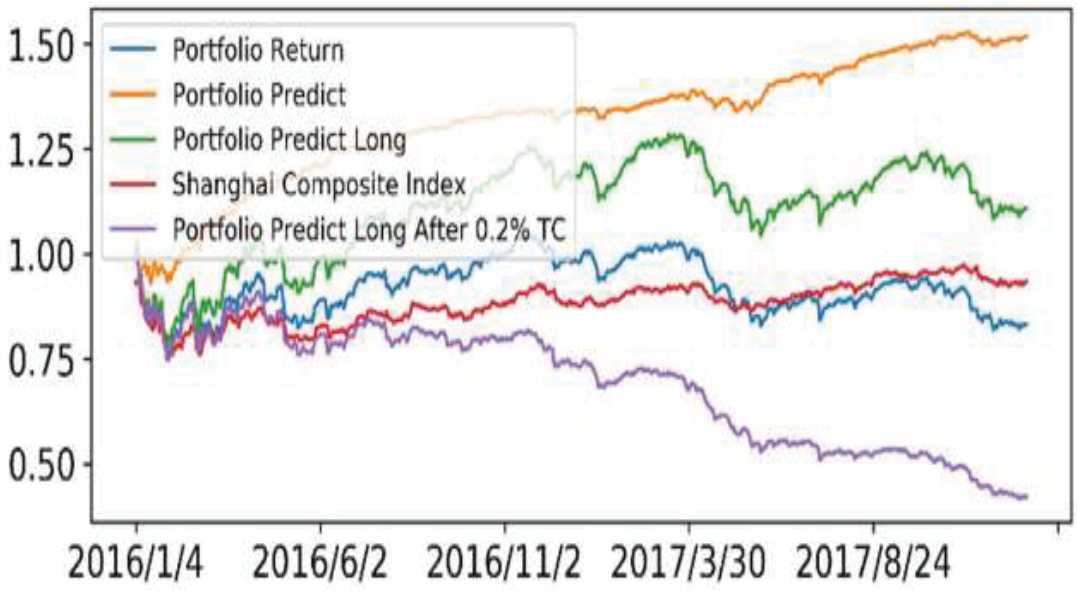


Figure 9. Portfolio Prediction [2]

Table 1. Results of prediction [2]

	Portfolio	Predict1	Predict2	Predict3	Index
Max Draw down	26.10%	9.70%	24.10%	59.04%	21.00%
Sharpe Ratio	-0.36	1.65	0.24	-1.76	-0.08
Sortino Ratio	-0.023	0.174	0.029	-0.139	-0.009

The above figures explain the results of prediction, the figure 9 show the graph of portfolio prediction and the table 1 shows the results of prediction. In table 1, Predict1 means the portfolio including the short and long. Predict2 means the portfolio only go long. Predict3 means the portfolio only go long after 0.2% transaction cost. The Index means Shanghai Composite Index.
Overall, this is a good method as it relies not only on one method, but selects one based upon the situation. And thus it has better chances of predicting more accurately than the traditional methods.

C. "Novel Stock Crisis Prediction Technique—A Study on Indian Stock Market**"** [3]
This paper presents a method for prediction of stock market crisis using a hybrid feature selection technique and XGBoost and DNN.

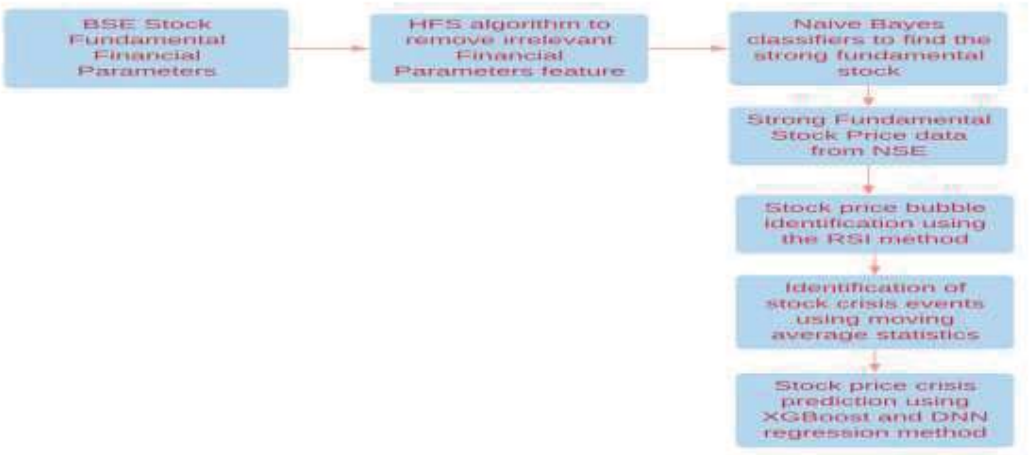


Figure 10. Proposed model [3]

The above figure shows the workflow of the proposed model. First, the data is collected from the stock market, then the HFS (Hybrid Feature Selection) algorithm is used to select the relevant stock features only. Then the Naive Bayes is used to predict the strong fundamental stock. Then the price data is collected from National Stock Exchange. Then the stock price bubble identification is done using the RSI (Relative Strength Index). Then the identification of stock crisis events is done using moving average statistics, then finally the stock price crisis is predicted using XGBoost and DNN.

Figure 11. Parameters List [3]

The above figure shows the list of all 42 parameters taken into account. Out of this list, a few parameters will be taken for the prediction of the stock price.

Figure 12. The Hybrid Feature Selection Algorithm [3]

The above figure shows the HFS (Hybrid Feature Selection) method that comprises of the RFE (Recursive Feature Elimination) and BFS (Boruta Feature Elimination) techniques. After this, the features in the intersection of the results of both are taken as the final features.

Stock Price Bubble Identification: [3]
Relative Strength Index (RSI) statistics are used to find the bubble in stock price. The RSI technical indicator value ranges from 0 to 100. The RSI values below 30 indicates that the stock price is oversold, and RSI values above 70 indicates the overbought levels. When the RSI indicator value reaches above 70, there is a high chance that stock price is falling. Most of the existing work RSI computed is based on 14 days, However, in this approach, they have considered 200 days in RSI to find the stock price bubble.
The reason for doing this is 14 days is used for intra-day trading and not for the long term.

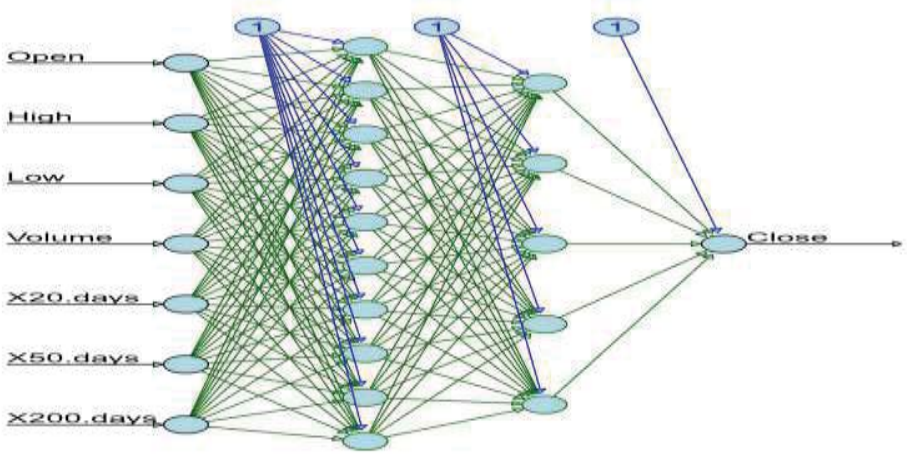


Figure 13. The Delayed Neural Network [3]

The above figure shows the structure of the Delayed Neural Network for the prediction of crisis.
Results: [3]

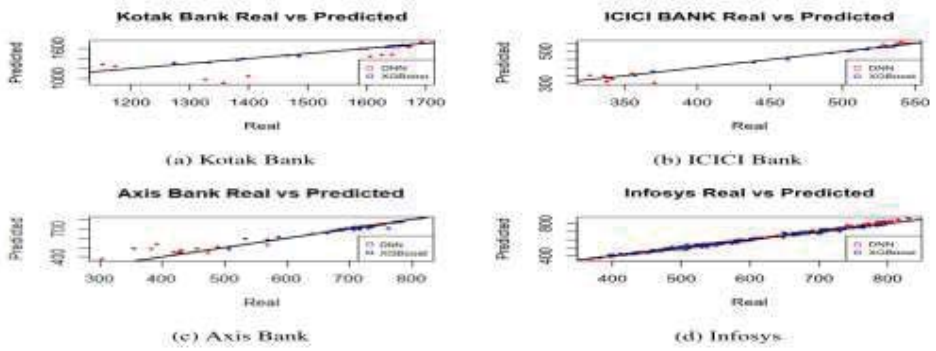


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Figure 14. Results of XGBoost and DNN methods [3]

The above figure shows the results of the predictions using both, the XGBoost and DNN.
Overall, this is a good method as it takes only required features into account and finds strong stocks. And it predicts for both, the long and short.

D. "One Step Ahead: A Framework for Detecting Unexpected Incidents and Predicting the Stock Markets**"** [4]
This paper aims to predict the short term stock prices by taking into account the impact of news and social media, especially the terrorism news.

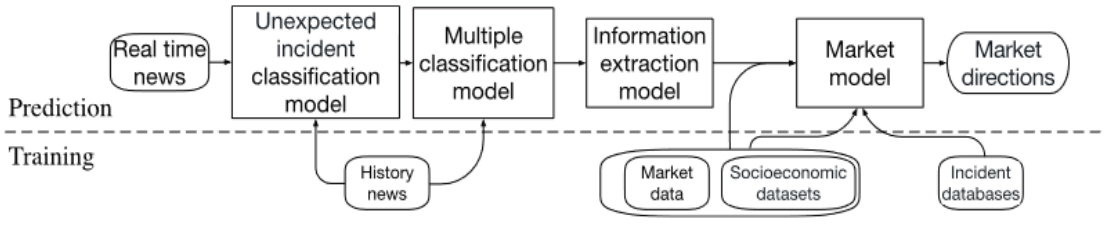

Figure 15. Basic Workflow of the proposed model [4]

The above figure shows the basic workflow of the proposed model. Firstly, the data is collected from the real time news, history news, stock market, incident databases and socioeconomic databases. Then all this data is

given as input after performing the data cleaning. Then the model predicts based upon the data using algorithms like Decision Tree, Support Vector Machine, Logistic Regression and Random Forest.

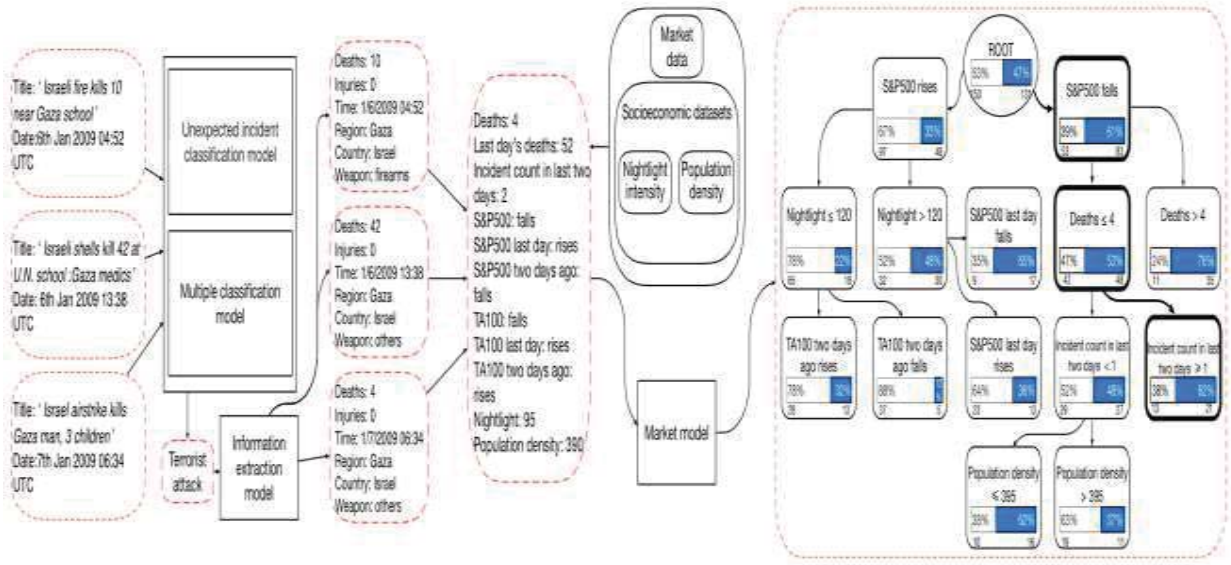

Figure 16. Sample prediction of the proposed model [4]

Data Collection: [4]
News Data is collected from various news portals such as Reuters, Twitter etc. [4]
Market Data is collected from Major Indices data such as IGBC (Columbia Stock Exchange General Index), TA100 (Tel Aviv Stock Exchange General Index), IGBM (Madrid Stock Exchange) etc. [4]
Terrorism Data is obtained from the GTD (Global Terrorism Database). [4]
Socio-Economic Data is obtained from NASA's global nightlight intensity data (used to measure economic developments for areas where incidents happen) and SEDAC's gridded global population density data (to estimate the number of people directly affected by incidents). [4]

Table 2. Results of prediction [4]

	Days with Terrorist Attacks			**Days without Terrorist Attacks**		
Features	**Precision**	**Recall**	**F1**	**Precision**	**Recall**	**F1**
Market Only	51.6%	47.0%	49.2%	59.5%	53.2%	56.2%
Full Feature	64.8%	53.0%	58.3%	64.4%	56.1%	60.0%

Workflow: [4]
The sample prediction of this proposed model is shown in the figure 16. As we can see, firstly, the news data is collected and it is put through an incident classification model and a multiple classification model. Then if the data is relevant, it is sent to the information extraction model. The information extraction model takes out the information required and eliminated the unnecessary parts of the data. After this, the information is combined with the data from the market and socioeconomic data.

After this, the combined data is provided as an input to the market model, which predicts the market ups and downs. As we can see in the figure, the output has two percentages, the percentage on the left correspond to the market ups and the right to market downs.

Results: [4]

The table 2 shows the results of the prediction. And as we can see, after combining the data, we get nearly 13% boost in prediction during the days with the terrorist attacks. Even in the days without terrorist attacks, we get a precision boost of nearly 5% after combining the data.

Table 3. Algorithm wise precision [4]

Algorithms	Precision	Recall	F1
Decision Tree	70.6%	57.6%	63.4%
Logistic Regression	61.2%	60.0%	60.6%
Random Forest	63.0%	54.4%	58.4%
Support Vector Machine	52.3%	50.0%	51.1%

The table 3 shows the algorithm wise precision for each of the algorithms used. As we can see, the decision tree algorithm has the highest precision of 70.6%.
Overall, this proposed model works fine and improves prediction accuracy for both, days with or without incidents. The model helps a lot in days with incidents, especially terrorism incidents.

E. "Forecasting Stock Market Indices Using Padding-Based Fourier Transform Denoising and Time Series Deep Learning Models**"** [5]

This model uses P-FTD (Padding based Fourier Transform Denoising) technique in order to remove noise (unnecessary part of the data) from the data and makes it more useful for prediction.

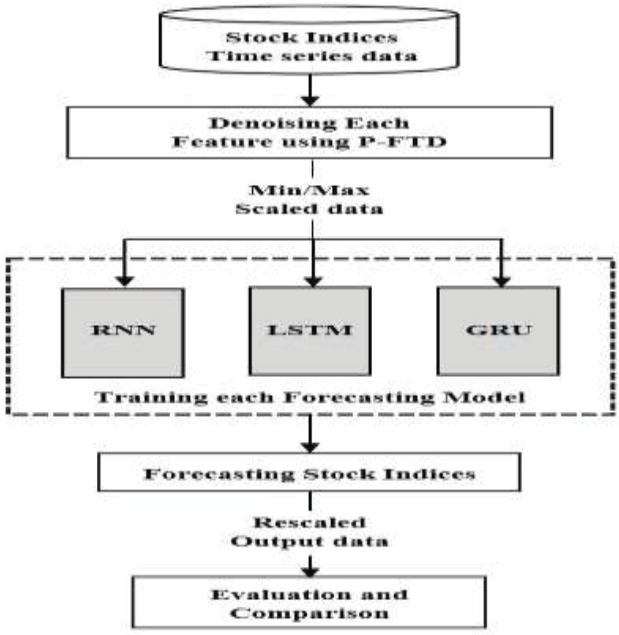

Figure 17. Proposed model's workflow [5]

The above figure shows the workflow of the model proposed. Firstly, the data is collected from the stock indices and the time series. Then each feature is denoised using the padding based fourier transform denoising technique. Then, the minimum or maximum scaled data is given as an input for the training of each forecasting model. The models used are RNN (Recurrent Neural Network), LSTM (Long Short Term Memory), GRU (Gated Recurrent Unit). After the training, the stock indices are forecasted. Then the output data is rescaled and the evaluations and comparisons are done.

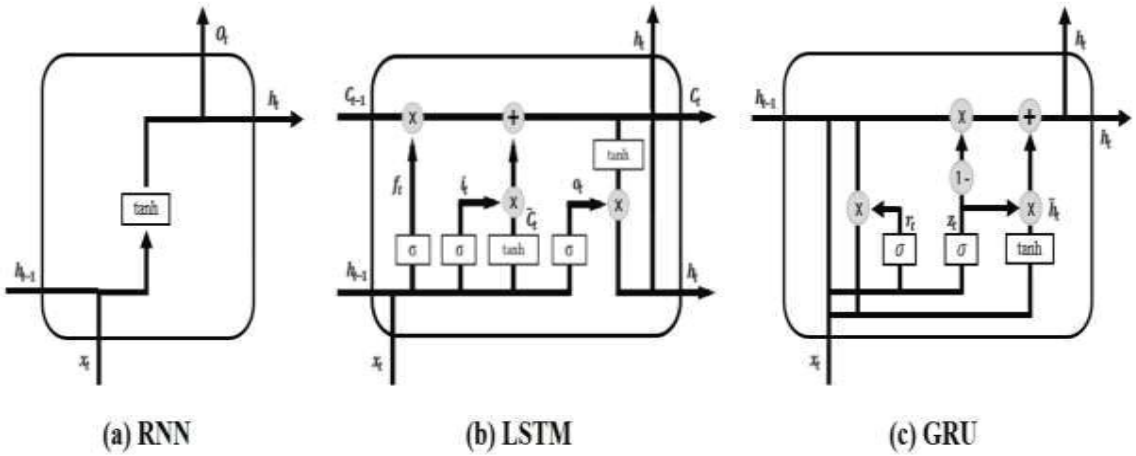

Figure 18. The Cell Diagrams of the models used [5]

The above figure shows the cell diagrams of the models used. It contains the paths and the functions used in them.

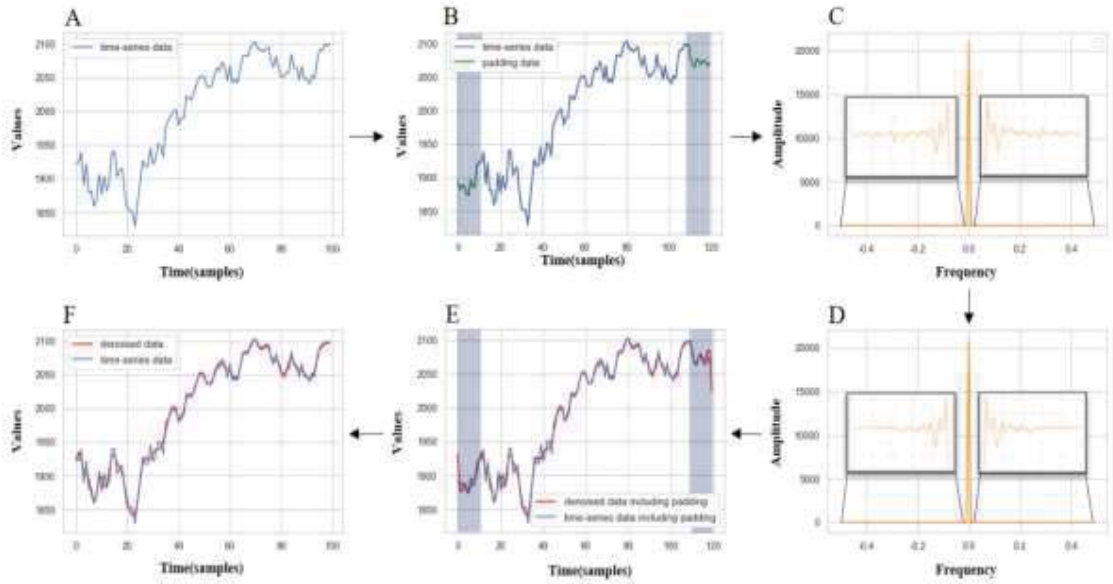

Figure 19. Illustration of the steps of P-FTD [5]

The figure 19 illustrates the steps of the padding based fourier transform denoising technique.

Figure 20. The sample of data before and after performing the P-FTD and the noise removed [5]

The above figure shows the sample of data before and after applying the padding based fourier transfom denoising technique. We can see that how much unnecessary data was removed after applying the padding based fourier transform denoising.

Data Used: [5]
The Standard & Poor 500 (S&P500) index (It is an index that tracks the performance of 500 large companies listed in the US Stock Exchange)
KOSPI (It is the Korea Composite Stock Price Index)
SSE (It is the Shanghai Stock Exchange)

Results

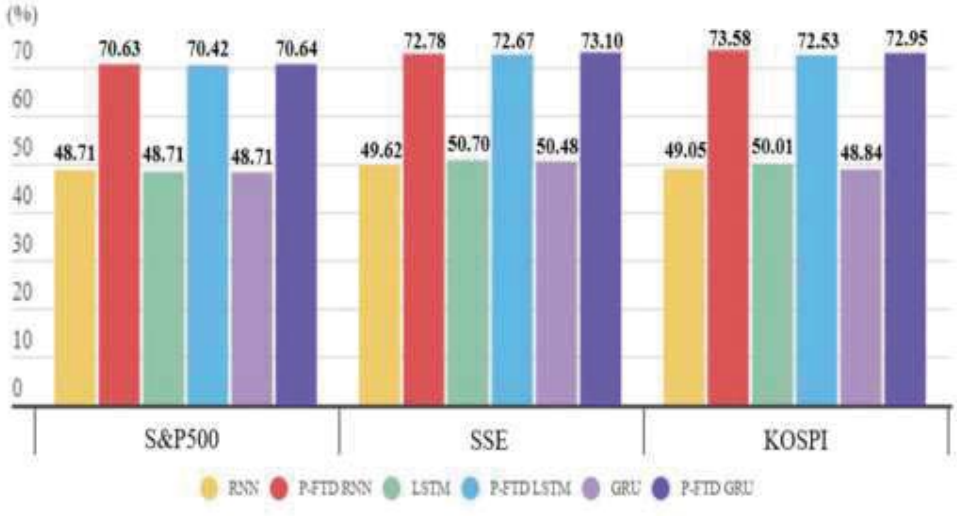

Figure 21. Prediction accuracy comparison before and after [5]

The above figure shows the prediction accuracies for each index and model before and after applying the padding based fourier transform denoising technique. As we can see, after applying the padding based fourier transform denoising, we get a boost of more than 20% for each model's prediction accuracy.
Overall, this model is really useful as it not only reduces the data to process, but also gives a really huge boost to the prediction accuracy.

Summary of Papers:

Sr No.	Name of the Paper	Publication Details	Proposed Conceptualization	Tools Used	Research Possibility
1	A Hybrid Approach of Bayesian Structural Time Series With LSTM to Identify the Influence of News Sentiment on short term forecasting of stock price [1]	IEEE Transactions on Social Computational Systems, 2021	A method created using combining BST with LSTM for better prediction of short term stock prices than the traditional models	R and Python, SentiWordNet, Slice Matrix I-O	The Algorithm can be further optimized in order to minimize the error
2	Stock Trend Prediction using Candlestick Charting and Ensemble Machine Learning Techniques with a Novel Feature Engineering Scheme [2]	IEEE Access Volume 9, 2021	A method involving candlestick patterns and machine learning techniques to predict stock market trends	Python and R	Further improvising can be done in order to gain more accuracy
3	Novel Stock Crisis Prediction Technique: A Study on Indian Stock Market [3]	IEEE Access Volume 9, 2021	A method that uses a Hybrid Feature Selection Technique and DNN and XGBOOST	Python	The method can be improvised in order to gain better performance
4	One Step Ahead: A Framework for Detecting Unexpected Incidents and Predicting the Stock Markets [4]	IEEE Access Volume 9, 2021	A model created to predict the short term effects on stocks due to incidents	Python	A generalized model can also be created for all the anomalies (not just terrorist attacks)
5	Forecasting Stock Market Indices using Padding Based Fourier Transform Denoising and Time Series Deep Learning Models [5]	IEEE Access Volume 9, 2021	A method that uses Padding based Fourier Transform in order to denoise the data and then makes prediction for stock market indices	Python	The accuracy can be boosted even further by improvising

5. Conclusion

We studied several methods for the prediction of stock market. All of these methods surpassed the traditional methods by a lot. But the stock market is highly volatile, so even these methods can't give us accurate results all the time. We can also see that news, rumours etc. also have a good amount of impact on stock price for a short time.

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