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Review Paper



Applications of neural network based methods on stock market prediction: survey

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Abstract

Financial forecasting is one of the domineering fields of research, where investor's money is at stake due to the rise or fall of the stock prices which unpredictable and fluctuating. Basically as the demand for stock markets has been rising at an unprecedented rate so its prediction becomes all the more exciting and challenging. Prediction of the forthcoming stock prices mostly Artificial Neural Network (ANN) based models are taken into account. The other models such as Bio-inspired Computing, Fuzzy network model etc., considering statistical measures, technical indicators and fundamental indicators are also explored by the researchers in the field of financial application. Ann's development has led the investors for hoping the best prediction because networks included great capability of machine learning such as classification and prediction. Most optimization techniques are being used for training the weights of prediction models. Currently, various models of ANN-based stock price prediction have been presented and successfully being carried to many fields of Financial Engineering. This survey aims to study the mostly used ANN and related representations on Stock Market Prediction and make a proportional analysis between them.

Keywords: *ANN; Financial Forecasting; Stock Market Prediction.*

1. Introduction

Stock market involves a zone of open interest where shares are bought and sold by investors and company respectively. Here the investors include the public for the purpose of rising of the capital and a bond of security is involved in between the two. The importance of stock market can be analyzed from the fact that it provides a ground for raising money with the help of stock shares and commercial bonds. With the help of this, even the investors are benefited as they are given the shares of company's profit. As a financial barometer, stock market has influenced every strata of society, from the average family to the wealthiest. Stock market prediction involves the pre forecasting of the probable share prices based on past share prices analysis. Some of the factors which tends to affect the stock market prices are the internal developments within the company, world events (such as world war, natural disaster, and terrorism), inflation and interest rate, exchange rates with foreign currencies, and the last one is advertisement or hype of new event or product which results in promotional event.

Stock market analysis is gaining grounds of popularity may be due to its volatility, fluctuating and inconsistent nature, for which it becomes difficult for investors to preplan their strategy of investment in share market. Due to which it becomes one of the important reasons for prediction of future possible values of stock prices. The volatile nature of stock market here refers to the instabilities of the market value for returns of the shares held by the investors. Being volatile in nature it becomes difficult for accuracy and better guidance of investors. Due to its volatility, the result predicted are not 100% accurate but it helps investors to anticipate the future. Stock prediction should be as accurate as possible, so that it can be helpful, due to which technical analysis is performed prior to prediction. Analysis of previous historical data helps in getting an overview of changes in day to day basis and creating a statistical graph. Another reason for increase in the demand of stock market prediction is its challenge of being dynamic and possesses many hypothetical and experimental limitations. Any predictive model can be broadly categorized into following categories: non-parametric, parametric and semi-parametric model, where semi-parametric model includes features of both parametric and non-parametric model. Predictive modeling is a statistical based concept. The model may use a complex neural network or maybe a simple statistical formula. Some of the mostly used prediction tools in previous works are ANN (Artificial Neural Network), FLANN (Functional Link Artificial Neural Network), BPNN (Back Propagation Neural Network) and some others are RBFNN (Radial Basis Function Neural Network), ELM (Extreme Learning Machine), etc. Here, the above techniques' application in stock market prediction is analyzed. All the above techniques have their own pros and cons. The practical applications of some of the techniques on stock market analysis are proposed. Here are overviews to some of the above methods with a brief description. ANN is an interconnected group of nodes, which functions similarly to that of a human brain and is very much preferred due to its superiority and variations [1]. ANN contains several other models, for example, MLP (Multi-Layer Perceptron Network), Autoencoder etc. Hadavandi et al. [2] anticipated a ANN model based on genetic fuzzy system for predicting the next day's stock prices as well as overcoming the shortcomings of ANN model alone, as every Artificial Intelligence (AI) model has its own pros and cons. BPNN is one of the techniques which are most often used for stock market prediction due to its complexity and amalgamated multi-layered neural network [3] and here the author proposes a modified BPNN technique overcoming some of its previous drawbacks. Zhang et al. [4] proposed a hybridized model based on EMD-BPNN, where EMD (Empirical Mode Decomposition) is used to

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break down the time series dataset to IMF (Intrinsic Mode Function) at several levels and then BPNN is used for training. There are a lot of complexities and differences between multi-layer neural network and single layer neural network. Due to which FLANN was developed to minimize such complexities and the shortcomings [5]. Bebarta et al. compared all the types of FLANN models and proved its efficiency and simplicity compared to other multi-layer ANN models [6]. RBFNN were at first used for solving the interpolation problems (fitting a curve exactly among a set of pints) [7]. Similar to FLANN, RBFNN is also used for minimizing limitations of ANN model in stock prediction [8]. ELM are feed-forward neural networks which is being used for the process of classification, clustering, feature selection, regression sparse approximation, and compression in single or multi-layer hidden nodes in which the parameters need not be adjusted. Wang et al. [9] proposed a multi-kernel learning based ELM model which not only enhances the performance but also is a fast learning model. The model includes MKL-ELM, K-ELM, SVM which is developed by using HKEx 2001 stock market datasets and proves to be better in comparison to B-ELM and BPNN and MKL-ELM proved to better amongst all. RBFNN is a feed-forward neural network which is double layered. It was first presented as a solution in the real multivariate interpolation problem. Rakhi Mahanta et al. proposed an optimized RBF network model and compared it with MLP for proving its authenticity in the field of prediction. Here Nifty data set is used for experiment purpose [10].

The following contents of the paper consists of the following: section 2 focuses on the methods of application of different techniques and their hybrid use in stock market prediction and a comparative study along with other optimized recently developed models. This is followed by a summarization of ANN models as the conclusion in the last section.

2. Literature survey

2.1. ANN

The future of an investor in a stock market highly depends on the future of the Sensex which is highly unpredictable; Even a small investor can gain a lot. Due to which a lot of interest are paid by the researchers to propose an algorithm which fulfills all requirements and gives a nearly accurate model. Due to the complex, volatile and fluctuating features of the stock market's everyday prices, it is highly difficult to predict an accurate model for such dynamic characteristics. For this reason, several distinct models have been tried in all the fields of financial market, which still contain their own merits and demerits. The prediction approaches fall generally into three categories. First is fundamental analysis, where the company's past performance is evaluated along with trustworthiness of its accounts. Here the company's historical as well as present state is taken into account. Second is, technical analysis, seek to foresee the future prices based on the trends of the past price. Most common factors are the company's economic conditions and its working circumstances. Lastly the technological analysis, which involves the use of data mining models such as ANN, SVM (Support Vector Machine), GA (Genetic Algorithm) Fuzzy Logic, evolutionary computation, etc. The model which is a lot preferred for stock market analysis in ANN is feed-forward neural network.

ANN has been originating to deliver very promising results in case of stock prediction. A several dynamic and hybrid models have been proposed which gives promising results in this regard. Kara et al. presented a comparative analysis between ANN and SVM model by attempting to predict the course of movement of stock prices using the Istanbul stock exchange. It was figured that both the process can be equally emphasized and taken into account in stock prediction. But ANN performed in an average a slight better in performance as compared to SVM [11]. Laboissiere et al. proposed a model based [12] on ANN with an objective to solve the difficulty of calculation of maximum and minimum day stock prices using NASDAQ stock exchange indices for Brazilian Distribution Company was found to be effective. The prediction's performance was measured by involving Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) calculations. Moghaddam et al. in the paper tries to perform the [13] functioning mechanism and the effect of ANN on the daily NASDAQ stock exchange prediction. The above model uses the values of NASDAQ exchange rate of last four and nine working days along with week's day as the input parameters and it was proved that there is no difference between the performance of the two, may it be last four or nine working days. Both showed nearly the same value. Guresan et al. compares different types of ANN model, which are dynamic in nature, to prove the accuracy of each model for stock market [14] prediction and to provide an accurate model to reduce the shortcomings of using ANN model here. The model used here are MLP, DAN2 (Dynamic ANN), the hybridized ANN which uses GARCH (Generalized Autoregressive Conditional Heteroscedasticity) for the extraction of innovative input variables. Gocken et al. uses hybrid ANN for capturing the connection between the stock market and the technical indicators for the duration undertaken, which [15] consists of exploiting proficiencies of GA and Harmony Search (HS), indicating the use of selection of the most appropriate technical indicator. Here both HS-ANN and GA-ANN were highly efficient for stock analysis but both had some shortcomings which could be avoided with the help of selection, cross-over and mutation operators. There is a list of other proposed model from [16-23] given in the Table 1 which clearly depicts the further use of ANN
model.

2.2. BPNN

Due to the noisy data of stock prices, it is quite a difficult task for the researchers to make a tool with accurate prediction. So Wang et al. proposed a BPNN based [24] approach called as Wavelet Denoising-based Back Propagation (WDBP) neural network. Here Shanghai Composite Index time period of January 1993 to December 2009 is taken into account for proving WDBP's efficiency in stock prediction. The projected technique is compared with simple BPNN network. Here the dataset is divided into layers, as each level contains a low and a high occurrence. Then BPNN is set up on low-frequency single for prediction of future value. Here the Wavelet transform is a very efficient preprocessing tool. Hsieh proposed an integrated design of [25] experiment (DOE) and BPNN for the construction of a robust platform to improve the estimation accuracy under the influence of robust DOE-based predictor. The Taiwan Stock Exchange (TWSE) and Hang Seng Index (HSI) are taken as dataset for the implementation of the above model. The proposed model can very efficiently increase the rate of prediction of stock's discrepancy. Yizhen et al. projected a hybrid model involving [26] BPNN and genetic algorithm (GA) on the Shanghai stock index. The model proposed is an intricate nonlinear stochastic system which has high application value. Here BPNN is used in forecasting the trend and GA is used in optimization of to optimize the parameter, such as weight and structure. Khao et al. proposed a BPNN model trained by [27] time and profit factor along with simple recurrent neural network on S&P 500 of U.S. stock exchange. It was proposed for the use of GA as the future work to be implemented as this model worked perfectly with the stock prices. Table 2 portrays some other enhanced models of BPNN from [28 – 30].

2.3. FLANN

A FLANN model can also be of different types like Power FLANN (PFLANN), Legendre FLANN (LeFLANN), Laguerre FLANN (LFLANN) and Chebyshev FLANN (CFLANN). Each of the above models can be used for time series data prediction. Das et al. gave forward a FLANN model trained by fuzzy for prediction of the closing price of Yahoo Inc, Nokia and Bank of America [31]. The result is then put in comparison to the constraints of the FLANN model trained by GA. A trigonometric FLANN model projected by Majhi

et al. for short term and long term prediction [32] of prices of S&P 500 and DJIA stock price. The developed model uses the LMS (least mean square) as well as the RLS (recursive least square) for the weights of the model, to be trained as per requirements. In comparison to LMS based prediction, RLS is more appropriate because of requiring significantly less test to train the model. Table 3 portrays some other enhanced techniques of FLANN from [33-36].

Table 1: The Findings of the Model Using ANN Technique

Domain	Sources of Data	Proposed model	Findings
Stock Market Prediction	NSE data (2008 to 2012), New York stock exchange	ANN model (MLP) using C# programming language	Stock market prediction requires large amount of data for the tools to be trained.
Stock Market Prediction	Hana, Synex, LPN stock prices of Thailand	Simple static cascade-forward back-propagation ANN	Ann is used for calculating the effects of stock repurchase and it is fruitful after several times the dataset is trained.
Stock Market Prediction	OTC Exchange of Taiwan	ANN and DT (C&RT) (Decision tree) as well as a hybrid model (both ANN and DT)	ANN model is far more efficient than the C&RT model or hybrid model. The proposed hybrid model needs development.
Stock Market Prediction	Shanghai stock exchange	capital asset pricing model (CAPM)	CAPM outperform Fama and French's (3-factor) model in stock market prediction.
Stock Market Prediction	Petrobras' PETR4 stock	ANN with different analysis technique	ANN was very fruitful for prediction as well as enhancement of the directional prediction index.
Stock Market Prediction	Tehran Stock Exchange	MLP along with Principal Component Analysis(PCA)	ANN model has proven its superiority compared to others. Other models like genetic algorithm models, Fraktal models and non-linear regression models can also be applied here.
Stock Market Prediction	Microsoft Corp., Goldman Sachs Group Inc. stock	Bayesian regularized artificial neural network	The projected model performed as good as other progressive models without preprocessing the need of data.
Stock Market Prediction	Tehran Stock Market (2007-2012)	integration fuzzy C-means (FCM), ANN and data envelopment analysis (DEA)	It is fruitful for companies where data is available in partial form and not in total, as it forms clusters.

Table 2: The Findings of the Model Using BPNN Technique

Domain	Sources of Data	Proposed model	Findings
Stock Market Prediction	Taiwan Top 50 Exchange Traded Fund (ETF), Shenzhen Composite, and S&P 500	Dynamic normalized BPNN (BPNN with novel normalized function)	This model provides a methodology of designing parameters for better performance, thus giving a comparatively a good result.
Stock Market Prediction	L&T stock market data, Air Quality data, Surface roughness, Concrete Strength data	GA and BPNN based Hybrid model	The proposed model proves to be in better standards compared to BPNN model in both multivariate and univariate data sets.
Stock Market Prediction	S&P 500	Hybrid model of improved bacterial chemotaxis optimization (BCO) and BPNN	The proposed model is better in performance in learning capacity and generalization.

Table 3: The Findings of the Model Using FLANN Technique

Domain	Sources of Data	Proposed model	Findings
Stock Market Prediction	DJIA S&P500 stock indices	Hybrid FFLANN (Feedback FLANN) with RLS	The model projected is superior in comparison to MLANN, RBFNN, and SVM under similar conditions.
Stock Market Prediction	S&P500and NIKKEI 225 data sets	recurrent computationally efficient FLANN (RCEFLANN) along with adaptive bio-inspired Firefly algorithm along with New Jersey–Maryland (PJM) energy market	It takes less computational overhead to predict acceptable consequences. And is even good at predicting electricity price prediction as the data set is taken for surety of result.
Mutual Fund Prediction	Birla Sun Life Equity Fund Growth, Franklin India Bluechip Fund - Growth, HDFC Top200- Growth, ICICI pro. Top100-Growth, UTI Equity Fund-Growth	Non-Linear improvised FLANN based prediction model	This model is used to calculate net asset value (NAV) of Indian stock exchanges which includes fewer computational weight and fast prediction capacity.
Stock Market Prediction	BSE (Bombay Stock Exchange), NSE, INFY	Differential Evolution based FLANN	The DE improved FLANN affords enhance performance as compared to RMSE and MAPE.

2.4. ELM

ELM can be implemented in different methods like classification, compression and spare coding in different methods, due to which multi-ELMs are used for the formation of multi-hidden layer network, deep learning, or hierarchical networks [37-39]. Gocken et al. developed an improved ELM model [40] consisting of an integration of GA, DE, PSO and weighted superposition attraction (WSA). The model was carried on the stock exchange of turkey. It was concluded that even after the presence of highly fluctuating data of stock prices the model was a great success in forecasting technique. They also suggested that the model could be tried on other stocks and instead of technical indicators; fundamental indicators could also be used. Ravi et al. develops a model on the oil and gas indices of Bombay stock exchange (BSE), as the sequential

alternatives of ELM, which is compared to BPNN with single hidden layer. The model is not in prerequisite of computation of the inverse of any matrix and has simple initialization [41]. Cavalcante et al. proposed a trader agent [42] which can not only compute technical indicators by itself but also take self-decisions on buying and selling of stocks for benefit. The involved mediator is built on a Single-hidden Layer Feedforward Neural Network (SLFN) jointly trained with OS-ELM (online sequential ELM), an alternative of ELM that can obtain data one-by-one and dynamically provide accommodated modifications in the market. The model is constructed on Brazilian stock exchange with increased amount of financial gain. Again the same author proposed another hybrid model of OS-ELM which [43] consists of explicit drift detection. Here the decision model gets updated in the presence of perceived drift in data and speeding up the forecast time by preserving equivalent precision. The data sets being used for estimating the accuracy of the proposed model are S&P 500 Index, Shanghai SSE Composite Index, and Apple Inc. stock prices.

X. Wang et al. proposed an OS-ELM with kernel-based model (OS-ELMK) after nonstationary stock price prediction, which was applied [44] to (Dow Jones Industrial Average) DJIA stock exchange. The above model can easily adapt to tune when new samples are added or removed. The speed of prediction is much faster as compared to online support vector regression (OLSVR) and ELMK. Table 4 portrays some other enhanced techniques of ELM from [45-50].

Table 4: The Findings of the Model Using ELM Technique

Domain	Sources of Data	Proposed model	Findings
Forex Market Prediction	USD to INR exchange rate and USD to EURO exchange rate	Hybridized ELM model i.e. an ELM model consisting of Jaya optimization technique	The model performs better than any other model if same condition is applied to FLANN and NN.
Stock Market Prediction	TianChi and BCS Stock Exchange	$\ell_{2,1}$ -norm and Random Fourier Mapping based Extreme Learning Machine($\ell_{2,1}$ RF-ELM)	Due to the presence of l2,1 RF-ELM, the inappropriate and terminated hidden neurons are eliminated to form a more discriminative and compressed hidden layer
Stock Market Prediction	Chinese segmentation software ICTCLAS for segmenting the sentences of market news and stock prices	A feature selection algorithm normalized relative discriminant Criterion (NRDC), as well as a new feature weighting algorithm (N-TF-IDF)	The proposed achieve better speed and accuracy in case of prediction in most cases. As it is a kernel-based learning model it can be extended to multi kernel-based learning model.
Stock Market Prediction	daily value of Petroleum sector Index	adaptive ensemble models of ELMs (AD-ELM)	The model here is used for outlier forecasting and outperforms the methods based on autoregression and ELM models.
Stock Market Prediction	Sea-water temperature, Sunspots and Santa Fe A	Optimally Pruned Extreme Learning Machine (OP-ELM)	OP-ELM is robust against peripheral or interrelated variable. The model can be used without computationally substantial variable selection techniques.
Stock Market Prediction	Shanghai stock index, Shenzhenv component, Vanke, Yunnan baiyao, China Petro Chemical, Baotou Rare Earth, Hefei, Fengle Seed, China Satellite	multi-feature ELM algorithm	In comparison to single feature wavelet technique, the recognized results were found to be more reliable, as it handles more information from the Sensex and prevents “masking effect”.

2.5. RBFNN

RBFNN is a two-layer feed-forward neural network. It was first presented as a solution in the real multivariate interpolation problem [51]. Sun et al. the method collectives the optimal [52] partition algorithm (OPA) with the RBFNN. The proposed model is compared with the HCM (hard c-means) algorithm shows that the suggested OPA method recollects obvious benefits in the precision of forecasting, simplification, and predicting trends. C. Quek et al. evaluated the effectiveness of 4 models of [53] neural network such as Feed Forward Neural Network, RBFNN, ANFIS (Adaptive Neuro-Fuzzy Inference System) and RSPOP (Rough Set based Pseudo Outer Product Rule) in predicting the impact of news on stock market prediction. Here RBFNN has considerably better values than FFNN but the best values are RSPOP with marginal error values. Feng et al. proposed an evolutional RBFNN on Taiwan stock index (TAIEX) including [54] a step-wise regression analysis (SRA). Computational models TAIEX are compared with other learning methodologies, which illustrates better presentation, not only increases the exactness of the stock price prediction but also enhances the win rate in the TAIEX trends. Minakshi Rout et al. worked on the optimization [55] of RBFNN. Accordingly, the RBFNN is considered as the best analyst. Wei Shen et al. Wu developed a model using RBFNN improved by artificial fish swarm (AFS) algorithm. AFS is used for optimizing [56] the k-means algorithm which leads to a better precision.

3. Conclusion

This paper demonstrated the different NNs model currently in use for predicting financial time series’ accuracy, speed and its parameters optimization. It gave emphasize basically on ANN, BPNN, RBFN, FLANN, ELM. Each and every model has their own merits and demerits and their superiority on other model. Amongst all ELM is the latest model used and gets easily hybridized with other explicit models. From here, it can be drawn that, ANN has the aptitude of generalizing and correctly inferring parts of the sample data set even if the sample contains unwanted information. Neural Network captures understated functional relationships even if it is hard to describe. Neural network model is accomplished in such a way that it learns from experience and provides a practically feasible way to solve real-world problems.

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