International Journal of Emerging Trends & Technology in Computer Science (IJETTCS)
Web Site: www.ijettcs.org Email: editor@ijettcs.org
Volume 6, Issue 3, May- June 2017 ISSN 2278-6856

Stock Market Prediction Using ANN, SVM, ELM: A Review

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Abstract

Now-a-days stock market has become a major research area due to its non-linear behaviour in stock prices. So, a discerning prediction model is required to minimize high risk and maximize returns associated with sock prices. Several studies give solid demonstrations that models adapting traditional regression techniques face compelling challenges in out-of sample predictability test due to model ambiguity and parameter inconstancy. Soft computing techniques are tenable methods for considerable forecasting outcomes. This paper is a review of Artificial Neural Networks (ANN), Support Vector Machines (SVM) and Extreme Learning Machines (ELM) attain and applied to predict stock prices. ANN is non- linear and non-parametric classifier which is viable for forecasting of stock prices. SVM uses the marginal values rather than average values for the classification prediction model. ELM uses fast training mechanism which is commercial for stock price prediction. Through this review it is unveil that these three data mining techniques are accustomed for studying and estimating stock market behavior.

Keywords: ANN, SVM, ELM.

1. INTRODUCTION

The financial (market) emporium and macroeconomic domain are composite, evolutionary and non- linear projectile approach. We should first understand what stock, stock prices, stock market are. Stock is kind of guarantee that symbolize right of possession or proprietorship in an organization and also claim to be a part of the organization's equity and profits. There are basically two types of stock: common and preferred. Common stock is the type of stock which allows the share holders to vote in the meetings and have access over their part of stock. Whereas preferred stock which although doesn't allows the share holders to vote but avails higher claims on the equity and earnings than those of common shares. Stock price means the price paid on an exchange of a security. This is the actual transaction of price between the sellers and the buyer in the financial emporium certain number of things can affect stock price like unpredictable behavior of market, current economic situations and prominence of the organization. Also the supply and demand factors directly affect the pricing of stocks. Stock market is a market where selling and buying of both listed and unlisted securities takes place. Stock market is the cluster of markets and exchanges where trading of stocks, bonds and other securities are done. It enables stock holders to participate in the economic achievements of the organization.

1. 1 Background of stock market

In 12th century France the main means of exchange between countries governing the credits of communities for agricultural work on account of the banks. In the middle of 13th century Venetian bankers started trading in government securities. In 14th century bankers of Pisa, Verona, Genoa and Florence started commercialism in government securities. In 1531, Antwerp Belgium advertised a stock exchange. In 1602 the first joint – stock company was founded which is the Dutch east India company. In 1773 the first officially stock exchange formed was London stock exchange (LSE). In 1790 the Philadelphia stock exchange was formed.

Previously stock market was known as stock exchange denotes a place where actual buying and selling takes place. With computerized trading and electronic communication networks like NASDAQ and BATs, manual involvement has been reduced. Automated trading platforms uses computer algorithms which gives high frequency trading thus forecasting model requires a robust technique which gives accurate prediction of prices so that profit can be maximized. In this review we are generally focusing on three data mining techniques which are summarized below.

1.2 Artificial neural networks (ANN)

An artificial neural network (ANN) is a computing model designed upon the functions and architecture of human cerebellum. ANN is also known as connectionist.ANN is a classifier and also a non-linear statistical data modeling tool which models the entangled relationship between the inputs and outputs or it classifies data into patterns. ANN is widely accepted owing its ability to attain and generalize adaptability, parallelism of data processing, robustness, and fault tolerance. ANN proved it to be a universal function approximate and is apt for modeling tool in various fields like data validation, sales fore casting, medicine, customer research, price forecasting. ANN provides a prediction model which acts as desirable tools that not only show a direction of stock price movement, but also indicates the most supposable price value of the stock.

1.3 Support vector machine (SVM)

In 1963 Vapnik and his co-workers developed Support vector machine (SVM). SVM is basically a regression method. It is a supervised machine learning technique, generally used for regression and classification analysis.

SVM is also known as probabilistic binary linear classifier. It can also perform non-linear classification with the usage of different types of kernels. SVM can be used to solve numerous real world problems such as text and hyper text categorization, classification of images, permutation test, weather forecasting, sales forecasting etc. SVM is widely accepted due to its remarkable advantages such as effective in high dimensional spaces, memory efficient, versatile as uses different kernel functions for different decision functions. Kernel selection is an important task in support vector machines.

1.4 Extreme learning machines (ELM)

Extreme learning machine (ELM) is the type of feed-forward neural network used for basically classification and regression but only with one layer for hidden nodes and the weights which connects inputs to the hidden nodes are given haphazardly and weights are not updated ever. Guang Bin Huang has given the name extreme learning machine (ELM) to such kind of models. These ELM models come through good generalization performance and are much faster in terms of learning as compared with the model which is being trained with back-propagation. ELM does not face concerns like local minima, inappropriate learning rate and over-fitting issues etc. ELM can be implemented and feasible in different fields like artificial case, very large complex applications, protein sequence classification, many medical diagnosis applications, regression problems, compressive sensing, feature learning, clustering etc.

The remaining part of the article is presented as follows. Section 2 reviews stock markets made in use by different authors for their forecasting model. Section 3 describes different forecasting methodologies and specifies the benefits of the proposed models. Section 4 depicts the performance measures for the models. In Section 5, conclusions of this study are presented.

2 SURVEYED STOCK MARKETS

This study focuses on different stock market indexes. Some articles uses single stock market index for training and testing dataset, for forecasting model. However several other studies focus on different stock markets to give the prediction. This review includes data indexes from well developed market to emerging markets. Kijoung –Jae kinm et al. (2000) models the Korea stock price index (KOSPI), from January 1989 to December 1998. R.J Kuo et.al (1998) that uses as input the price of the Taiwan stock market from 1991 to 1997. Y. F. Wang attempt to forecast Taiwan stock market, data used for training and testing is from September 2000 to April 2001.Newyork stock Exchange Composite Index is examined by William Leigh et. al (2001), data taken as input from 1994 to 1996 Ajith et. al (2003) attempt to predict standard and poor's 500 index, NASDAQ and Daw Jones industrial average index. Kim et. al tries to forecast Korean composite stock price index (KOSPI). Egeli et. al (2003) studies Turkish stock market. S & P, CNX NIFTY market index of the national stock exchange is forecasted by Manish et. al (2005). Wei Huang et. al (2004) uses as input the price of the NIKKEI 225 Index on Tokyo Stock Exchange (TSE).Taiwan stock exchange is being examined by Chen et. al (2005). David Enke et. al (2005) model the S & P 500 index portfolio from March 1976 to December 1999. Robrat K. Lui et. al (2008) studies the Taiwan stock exchange corporation (TSEC) Epistar Corporation (EPISTAR), Silicon Integrated System Crop. (SIS) and UMC crop. (UMC), 2005.The Turkish stock market is examined by Senol et. al (2008).Yakup Kara et. al (2011) studies Istanbul stock exchange (ISE) national 100 indexes. Shom Prasad Das et. al (2012) that uses as input the price of the S & P CNX NIFTY, BANK NIFTY, S&P CNX 500 , CNX INFRA , & CNX 100 from NSE from 2007-2010. Intel, National Bank Shares and Microsoft daily closed stock price from NASDAQ is examined by Ahmad Kazem et. al (2012).Jonathan L.Tickno et. al (2013) for Microsoft Crop. and Goldman Sachs group Inc. Stock, from January 2010 to December2012. Takashi kimoto et. al (2013) studies TOPIX (Tokyo stock Exchange Prices Indexes) from January 1985 to September 1989.Xiaodongli et al. (2014) attempt to forecast H-Shore market in year 2001. Rajshree Dash et. al (2014) try to forecast BSE sensex, CNX Nifty, Nikkei 225 belongs to Tokyo stock exchange, S & P 500 belongs to US stock markets from 2010-2013.Jigar Patel et. al(2014) uses CNX Nifty and S & P Bombay stock exchange (BSE) sensor. HKEx 2001 stock market datasets are being used by Fengwang et. al(2014). Mustafa gocken et. al (2015) studies BIST100 index. C.M. Anish et. al (2015) model the DIIA and S & P 500.Michel Ballings et. al (2015) tries to forecast Amadeus database from bureau van Dijk. Hang Seng Index (HSI) 2001 is used by Feng Wang et. al (2015) for the prediction model. Asil Oztekin et. al (2016) tested on the Borsa Istanbul BIST 100 index from 2007 to 2014.Rajshree Dash et. al (2016) studies BSE SENSEX and S & P 500. Preuk suksiri et. al (2016) model the Stock Exchange of Thailand index (SET) standard and poor's 500 return indexes (S and P 500), stock market return index of Japan (Nikkei 225).

3 FORECASTING METHODOLOGY

In this review basically three data mining techniques are focused i.e., ANN, SVN, ELM for forecasting stock price. Some of the articles include indicators as inputs along with dataset so as to give batter prediction results. Pre-processing and proper sampling of input data influence forecasting performance. All the articles don't add data Pre-processing techniques but throughout the overall study. It has been observed that data pre-processing is advantageous. This entire survey is divided into 3 parts denoting the following there forecasting methodologies.

3.1 Artificial Neural Network (ANN)

An artificial neural network (ANN) is a computing model based upon the functions and architecture of human cerebellum. ANN is also known as connectionist.ANN is a

classifier and also a non-linear statistical data modeling tool which models the entangled relationship between the inputs and outputs or it classifies data into patterns. ANN is basically 3-layer architecture consists of input layer, hidden layer, output layer. The no. of input layer neurons symbolizes the no. of input features and the no. of nodes in the output layer symbolizes features in the target values. ANN is widely accepted owing its ability to attain and generalize adaptability, parallelism of data processing, robustness, and fault tolerance. To arrive at solutions, ANN inputs data samples rather than the entire data set which leads to saving of both time and money.ANN proved itself to be a universal function approximate and is apt for modeling tool in various fields like data validation, sales fore casting, medicine, customer research, price forecasting. In prediction & classification, the most common ANN is multilayer perceptron trained with back propagation algorithm. ANN provides a prediction model which acts as desirable tools that not only show a direction of stock price movement, but also indicates the most supposable price value of the stock. Articles including neural network as their forecasting model include [1] uses genetic algorithm with artificial neural network measuring the qualitative effect on the stock market using fuzzy inference rules. [2] Does feature discretization using GA and ANN is used for prediction for getting better performance than GALT-ANN model. [4] Does 4 experiments doing pattern recognition, feature selection, forecasting and finally cross-validation. [5] Takes 8 input variables and FFNN model for predicting price of NASDAQ indexes. [7] for predicting ISE market index values six kind of ANNs have been used including feed forward neural network, multilayer perceptron etc. [10] uses EDA based local linear wavelet neural network for stock market prediction model on Taiwan stock exchange data set. [11] An information gain technique is introduced which will be evaluating the predictive relations of various financial and economical variables. [12][19] ANN is compared with logistic regression methodology and shows that ANN outperforms. [18] The Bayesian ANN model is compared with ARIMA model and fusion model with weighted average and also the result shows that regularized Bayesian network gives an average of 98% fit for the future stock prices. [21] comparison is done between single stage approaches consisting of ANN, SVR,RF and also the fusion of these approaches i.e., SVR-ANN, SVR-SVR, SVR-RF and according to different performance measures SVR-ANN model performed best in prediction.[26] The result of the comparison shows that Random Forest is the best then SVM, Kernel factory, AdaBoost, neural network, K-NN and logistic Regression.[27] Combination of feature selection which is being done with factor analysis and prediction model FLANN trained with recursive least square algorithm. [28] Comparison is done between Harmonic search-ANN model and the result shows HS based ANN is dominant one. [30] CEFLANN with ELM approach is used as forecasting model.

3.2 Support Vector Machine (SVM)

In 1963 Vapnik and his co-workers developed Support vector machine (SVM). SVM is basically a regression method. SVM is a supervised machine learning technique generally used for regression and classification analysis. SVM is also known as probabilistic binary linear classifier. It can also perform non-linear classification with the usage of different types of kernels. SVM is acutely explicit kind of learning algorithm indicated as the capacity control of decision function and usage of kernel function. The maximal-margin classifier shows how SVM works. SVM can be used to learn polynomial, multi-layer perceptron (MLP) and radial basis function (RBF) classifiers. SVM works upon the principle of structural risk minimization that leads to the prevention of over-fitting problem. SVM can be used to solve numerous real world problems such as text and hyper text categorization, classification of images, permutation test, weather forecasting, sales forecasting etc. SVM is widely accepted due to its remarkable advantages such as effective in high dimensional spaces, memory efficient, versatile as uses different kernel functions for different decision functions. Kernel selection is an important task in support vector machines. Kernel approach is a set of algorithm for pattern analysis which will find and study generic types of relations in the datasets. Kernel functions are basically used for sequence data, images, graphs, vectors and texts. Kernel perceptron, SVM, PCA, canonical correlation analysis, spectral clustering etc. are the algorithms which can be used with kernel functions. Support vector regression or SVR is the process through which a function is approximated using espied data that in order trains the support vector machines. There are certain circumspections associated with SVM such as selection of free parameters generally calculated empirically and also it can be computationally costly training process. Articles including SVM as their forecasting model include [6] the SVM forecasting model is being compared with back-propagation neural network (BPN) and case-based reasoning (CBR) and the result shows that SVM is the best model out of these three models. [8] 12 technical indicators are taken as input for SVM, ANN, random forest (RF) forecasting model and SVM outperforms after comparison. [9], [15] stock market movement has been forecasted using SVM model. [16] A combination of three techniques used for prediction model i.e., chaotic mapping, firefly algorithm and support vector regression (SVR). The model has been compared with GA based SVR, firefly based SVR, ANN, adaptive neuro-fuzzy inference systems (ANFIS) and the proposed model performs best. [17]SVM gives better prediction than BPN. [24] A forecasting model is combination of Support vector machine (SVM) and teaching learning-based (TLBO). [31] Support vector machine is being compared with ANN, ANFIS and SVM outperforms.

3.3 Extreme Learning Machines (ELM)

Extreme learning machine (ELM) is the type of feed-forward neural network used for basically classification and regression but only with one layer for hidden nodes and the weights which connects inputs to the hidden nodes

are given haphazardly and weights are not updated ever. The weights associating hidden nodes with outputs are learned in single step. Guang Bin Huang has given the name extreme learning machine (ELM) to such kind of models. These ELM models come through good generalization performance and are much faster in terms of learning as compared with the model which is being trained with back-propagation. ELM does not require different algorithms for different SLFNs. To guarantee its generalization performance ELM follows Bartlett's theory. ELM contemplates multi-hidden layer networks as white box and trains the network layer-by-layer. ELM provides unified learning platform. ELM does not face concerns like local minima, inappropriate learning rate and over-fitting issues etc. ELM can be implemented and feasible in different fields like artificial case, very large complex applications, protein sequence classification, many medical diagnosis applications, regression problems, compressive sensing, feature learning, clustering etc. Although ELM proves to be extremely fast and in a better way in generalization, it has certain limitations. The random assignment of weights to the hidden nodes can have a negative impact on the network's versatility. The selection of hidden neurons is based on trial and error method that can result into unsatisfying outcome. Articles including ELM in their studies are as follows [20] a multi-kernel based ELM has been used as the forecasting technique which improves the prediction accuracy as well as proved to be much faster in terms of training and testing speed. [14] The Gray extreme learning machine model is compared with GARCH, BPN, GBPN, GMFLN models and GELM is proved to be superior among all these 5 models. [22] A self adaptive differential harmony search based optimized extreme learning machine (SADHS-OELM) has been implemented as a forecasting model which is being compared with ELM, DE-OELM, DE, SADHS and more two variants of HS algorithms. [23] The comparison is done between RBF-ELM, RBF-SVM and BP-NN and the performance measures gives higher prediction as well as gives faster prediction. [25] The forecasting model uses NRDC as feature selection algorithm and K-ELM as prediction technique. [29] Singular spectrum analysis is taken as a preprocessing tool and K-ELM as forecasting model which is compared with SVM, K-ELM, SSA-SVM, LS-SVM and SSA-LSSVM, and SSA-KELM gives highest accuracy with lowest training time.

3.4 Table

S.no.	Author & Year	Technique used	Comparison
1.	R.J. Kuo et.al (1998)	GFNN(Genetic Algorithm based Fuzzy Neural Network)	Quantitative and qualitative factors
2.	Kyoung-jae Kim et.al (2000)	GA-ANN(Genetic Algorithm based Artificial Neural Network)	BPLT-ANN, GALT-ANN and GAFD-ANN
3.	Y.F. Wang (2000)	Fuzzy grey prediction	No comparison
4.	William Leigh et.al (2001)	GA(Genetic Algorithm)	No comparison
5.	Ajith et.al (2003)	FFNN(Feed Forward Neural Network)	No comparison
6.	Kim et.al (2003)	SVM(Support Vector Machine)	SVM, CBR and BPN
7.	Egeli et.al (2003)	ANN(Artificial Neural Network)	No comparison
8.	Manish et.al (2005)	SVM(Support Vector Machine) and RF(Random Forest)	ANN, RF, SVM
9.	Wei Huang et.al (2005)	SVM(Support Vector Machine)	LDA, QDA, SVM
10.	Chen et.al (2005)	PNN(Particle Swarm Optimization-Neural Network)	GMM and PNN
11.	David Enke et.al (2005)	NN(Neural Network)	LR and NN
12.	Senol et.al (2008)	ANN(Artificial Neural Network)	ANN and Logistic regression
13.	Robert K. Lai et.al (2008)	GA-FDT(Genetic Algorithm based Fuzzy Decision Tree)	FDT and GA-FDT
14.	F.L. Chen et.al (2011)	GELM (Gray extreme learning machine)	BPN, GBPN, GMFLN, GARCH and GELM
15.	Yakup Kara et.al (2011)	ANN(Artificial Neural Network) and SVM(Support Vector Machine)	ANN and SVM
16.	Ahmad Kazem et.al (2012)	SVR (Support Vector Regression), Chaotic mapping and Firefly algorithm	ANN, ANFIS, firefly-based SVR, genetic algorithm-based SVR and chaotic genetic algorithm-based SVR
17.	Shom	SVM (Support	SVM and BP

	Prasad Das et.al (2012)	Vector Machine)	
18.	Jonathan L. Tickno et.al (2013)	Bayesian ANN(Bayesian Artificial Neural Network)	ARIMA and Bayesian ANN
19.	Takashi Kimoto et.al (2013)	ANN	ANN and multiple regression analysis
20.	Feng Wang et.al (2014)	MKL-ELM (Multi-Kernel Learning based Extreme Learning Machine)	BP-NN, SVM, ELM, K-ELM and MKL-ELM
21.	Jigar Patel et.al (2014)	ANN, SVR and RF	ANN, SVR, RF, SVR–ANN, SVR–SVR and SVR–RF.
22.	Rajashree Dash et.al (2014)	SADHS-OELM (Self Adaptive Differential Harmony Search Based Optimized Extreme Learning Machine)	ELM, DE-OELM, DE, SADHS, SADHS-OELM
23.	Xiaodong Li et.al (2014)	ELM (Extreme Learning Machine)	RBF ELM, RBF SVM, BP-NN
24.	Shom Prasad Das et.al (2015)	SVM-TLBO(Support Vector Machine with teaching–learning-based optimization)	SVM-TLBO, PSO-SVM and SVM.
25.	Feng Wang et.al (2015)	K-ELM (kernel-based Extreme Learning Machine)	K-ELM with NRDC and N-TFIDF, N-N-K-ELM, SVM and BP
26.	Michel Ballings et.al (2015)	ANN(Artificial Neural Network)	Random Forest, AdaBoost and Kernel Factory, Neural Networks, Logistic Regression, Support Vector Machines and K-Nearest Neighbour
27.	C.M. Anish et.al (2015)	FLANN(Functional Link Artificial Neural Network)	FLANN, MLANN, RBFNN and SVM
28.	Mustafa Göçken et.al (2015)	HS & GA based ANN(Harmony Search and Genetic Algorithm based Artificial Neural Network)	HS-ANN, GA-ANN and ANN
29.	Preuk Suksiri et.al (2016)	SSA-KELM(Singular Spectrum Analysis with Extreme Learning Machine)	LSSVM and SSA-LSSVM
30.	Rajashree Dash et.al (2016)	CEFLANN with ELM(Chebyshev Functional Link Artificial Neural Network with Extreme Learning Machine)	SVM, Naive Bayesian model, KNN and DT
31.	Asil Oztekin et.al (2016)	SVM(Support Vector Machine)	ANN, SVM, ANFIS

4 PERFORMANCE MEASURE

In this section performance of each forecasting model is analyzed through different performance measures and their accuracy, speed and feasibility is being evaluated and compared. Performance measures can be classified basically as statistical measures and non-statistical measures.

Statistical measures include mean square error (MSE), standard deviation (SD), mean absolute error (MAE), mean absolute deviation (MAD), auto correlation, correlation coefficient, squared correlation, root mean square error (RMSE) etc. In this review it is noticed that many researchers used RMSE, MAE and MSE as their performance measure. [2] Uses average deviation as a performance measure. [18] MAPE is used to compute the performance of Bayesian regularized artificial neural network. [19] Uses coefficient correlation as the performance measure to show feasibility of the model. [11] Author used Pearson-correlation and root mean squared error for measuring the performance of forecasting model. [16] MAPE and MSE are used as the performance measure.

Non-statistical measures are the performance measures which are associated with the economical background of the forecasting model. Hit rate is the most commonly used non-statistical performance measure. [9] Uses hit ratio as the performance measure of the model. [5] Also used hit rate as one of the performance measure.

5 CONCLUSION

This review surveyed articles that have used artificial neural network (ANN), support vector machine (SVM), and extreme learning machine (ELM) as a forecasting model for stock prices. This study pinpoints different stock markets, different forecasting methodologies, model comparisons and performance measures. From the survey we can conclude that data mining techniques outperforms other conventional models in many cases. And also data processing gives better prediction results and provides better prediction direction. Through this study it is unveil that these three data mining techniques are accustomed for studying and estimating stock market behavior.

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