Hybridization of Wavelet Transform and ANN Techniques as Stock Prediction Model

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Abstract: Stock market data are non-linear and unpredictable most of the time, hence traditional techniques are not much reliable for stock prediction. Intelligent techniques like Artificial Neural Networks (ANN) may be the best choice for the same. Also wavelet transform is a technique which may be utilized for preprocessing of non-linear stock data. This paper presents hybridization of these two techniques as stock prediction model in which a type of Wavelet transform known as Stationary Wavelet Transform (SWT) is used for data de-noising and ANN is used for prediction. Feature extraction using various technical indicators was also applied followed by feature selection. Stock Data (BSE 30) with four features as open, high, low and close were used as raw material to check the performance of hybrid prediction model. Feature Extraction and selection methods are then used and total seven features out of sixteen extracted features have been selected for the prediction and achieved 2.614% and 2.627% of MAPE in case of Error Back Propagation Network (EBPN) and Radial Basis Function Network (RBFN) respectively.

Keywords: Artificial Neural Network (ANN), Wavelet Transformation (WT), Stationary Wavelet Transform (SWT), Feature Extraction and Selection.

I. INTRODUCTION

Accuracy in stock price prediction is a key issue for the investors and fund managers. A number of methods applied to develop more sophisticated models for stock price prediction using many intelligent techniques [10]. Due to non linear nature of stock data it is very difficult to predict it accurately. Some efficient de-noising techniques like wavelet transform may be very helpful in this regard. This paper presents an application of wavelet transform (WT) for de-noising of stock data as data preprocessing before feeding these data to any predictive model like Artificial Neural Network (ANN). Paper also explores Feature Extraction and Feature Selection techniques [1] to develop a sophisticated predictive model.

In the financial domain many authors have used these techniques for accurate prediction of stock market. Prediction of stock market using comparative study of ARIMA and RBFN is presented [17] and concluded that RBFN model is preferable than ARIMA model to predict future value of stock data. Another author [16] explored about combination of RBFN with other techniques such as Fuzzy Logic, Neural Network and Genetic Algorithm. Applications of wavelet transform and its advantage over Fourier transform for analyzing non-stationary signals is explained by [7]. Another author [9] has worked on reducing unwanted noise signal from digital signals through wavelet by using MATLAB-Simulink. A forecasting model based on Hybrid of Discrete Wavelet Transform (DWT) and Artificial Neural Network (ANN) is presented [14] and the result proved that hybrid of DWT and ANN achieved better result as compare to model without wavelet technique.

Feature extraction and selection were applied also in this paper; sixteen features are extracted from stock data using technical indicators suggested by various financial experts and prepared to be de-noised using WT technique. The current research work has three folds: In first fold smoothing of stock market data has been done using wavelet filter [2] technique known as SWT while in the second fold feature extraction and feature selection techniques [5] have been applied while in the third fold preprocessed stock data is used to predict next day close price using [8] ANN techniques.

II. WAVELET TRANSFORM AND ARTIFICIAL NEURAL NETWORK

A wavelet is a small wave, which has its energy concentrated in time to give a tool for the analysis of transient, non-stationary or time varying phenomenon. It still has the oscillating wave like characteristic (as Fourier analysis) but also has the ability to allow simultaneous time and frequency analysis with a flexible mathematical foundation. Wavelets are a powerful statistical tool [6-7] which can be used for a wide range of applications. There are different types of WT, in this paper we have used SWT (Stationary Wavelet Transform) [9] for data smoothing

ANN may be defined as an information processing model. The key element of ANN is novel structure of its information processing system [4]. There are different types of techniques used in ANN [15], in this paper we have used two ANN techniques called EBPN (Error Back Propagation Network) and RBFN (Radial Basis Function Network). RBFN and EBPN are powerful techniques for interpolation in multidimensional space. A RBF in RBFN is a function which has built into a distance criterion with respect to a center. RBF neural networks [16] have the advantage of not suffering from local minima in the same way as Multi-Layer Perceptrons. EBPN is powerful prediction technique which is based on various tuning parameters and the result may be improved by these tuning parameters they are: Learning rate and momentum factor. Where learning rate (α) updates the connecting weights in a neural network and other one is very efficient and commonly used method that allow a large learning rate without oscillation is by adding a momentum factor to the normal gradient descent method.

III. HYBRID OF SWT AND ANN

Overall process of applying SWT [12] and ANN is shown in form of framework in Figure 1, the normalized data with initial 4 features: open, close, low and high of stock data are used for feature extraction [11] using technical indicators suggested by financial experts, a total of 16 features are extracted from these 4 features. The new stock data with all these 16 features are further given to SWT for data smoothing, various parameters of SWT like decomposition level and threshold value were set based on trial and error method. After applying SWT technique, smooth data without any noise has been obtained and provided to the next stage for prediction. The detail of each stage is explained in more detail as below:

A. Data Preprocessing Stage

Time series data are nonlinear and noisy by nature and these noisy data might degrade the quality of discovered pattern. A MATLAB GUI tool of wavelet transform is used to apply SWT for de-noising stock data. This tool provides various options to set the parameter for smoothing stock data in desired way. The level of decomposition of stock data signal is also very important in order to improve the shape of delta signal. Figure 2 depicts the noisy signal of time series stock data from Aug-2009 to Oct-2014 which produces less prediction accuracy. Stock data with 16 features are given to SWT one-by-one, which produces decomposed signals (See lower left part of Figure 4) ,these decomposed signals further constructs smooth signal as shown in Figure 3 and helps to construct smooth signal as outcome.

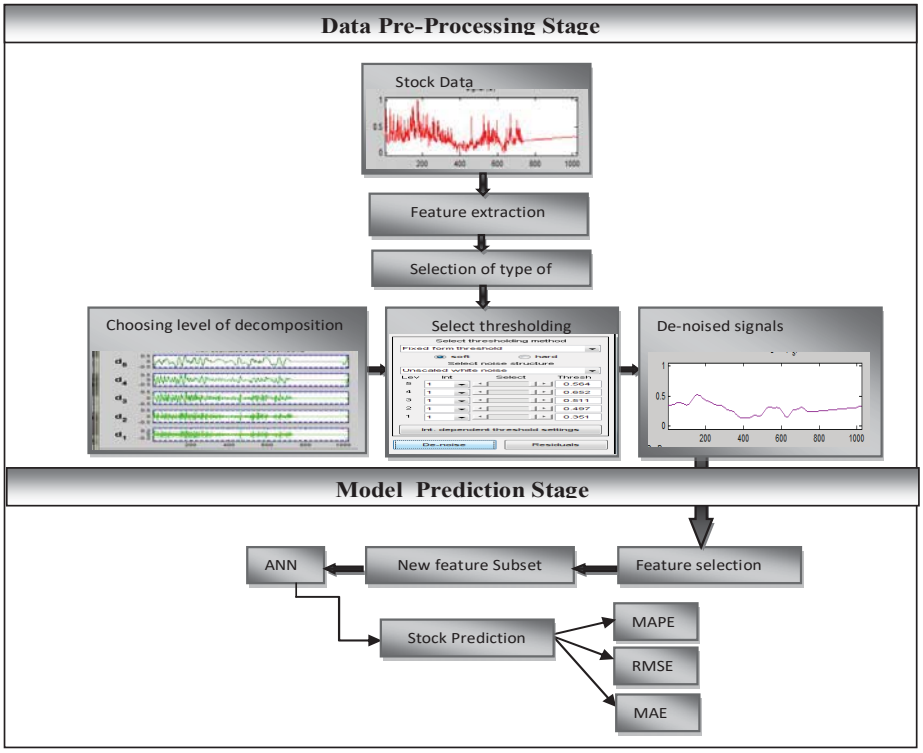


Figure 1: Frame work of hybrid of SWT and ANN

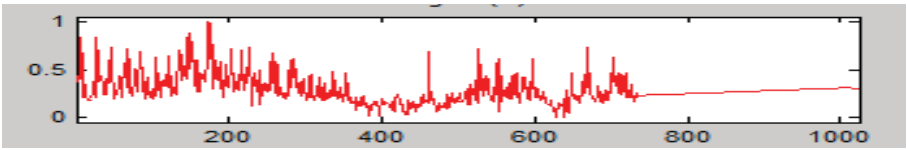


Figure 2: Signal before preprocessing

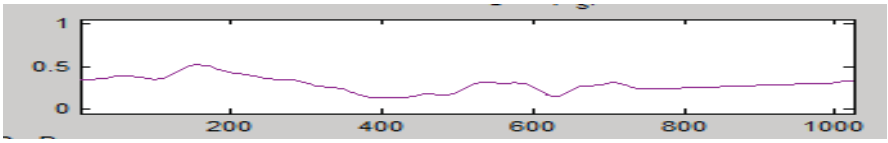


Figure 3: Signal after preprocessing using SWT

After de-noising of each feature of stock data using SWT, as explained above, signals were converted in form of numeric data. This data set along with original next-day-close price (normalized) is used for further process.

In the next step, ranking based feature selection techniques [13] have been applied. Feature selection is basically a process of selecting best feature subset. It removes irrelevant features because they might degrade the quality of discovered patterns. A feature selections techniques automatically discover the best features and it helps to solve the problems of having too much data that is of little value. Total of 16 features are extracted and then 7 best features are selected based on ranking based feature selection technique.

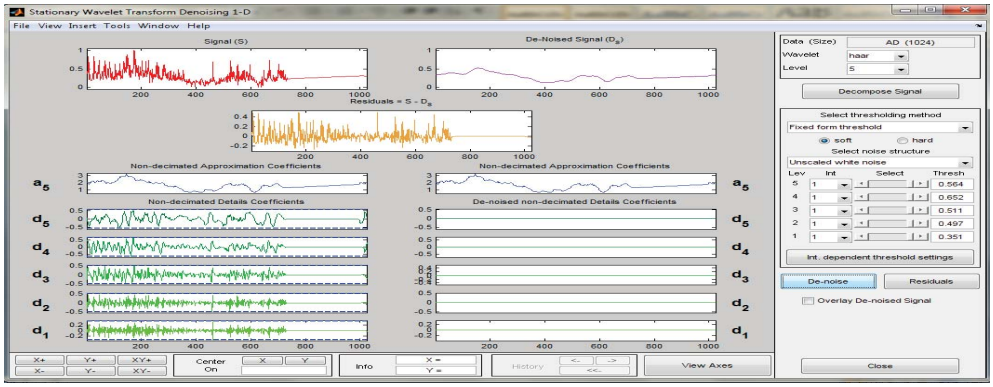


Figure 4: GUI of MATLAB for smoothing stock data after De-noising.

B. Model Prediction Stage

This stage emphasizes about the prediction of stock data through preprocessed data obtained in data preprocessing stage as explained above. A new features subset data with 7 features are then given to ANNs for next day close price prediction. Hybrid of SWT and ANN model is verified in terms of following error measures:

$$MAE = \frac{\sum_{i=0}^{n} |Y_{p,i} - Y_{a,i}|}{n} \quad (1)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=0}^{n} (Y_{a,i} - Y_{p,i})^2} \quad (2)$$

$$MAPE = \frac{\sum_{i=0}^{n} |Y_{p,i} - Y_{a,i}|}{n} \times 100 \quad (3)$$

C. Result Analysis

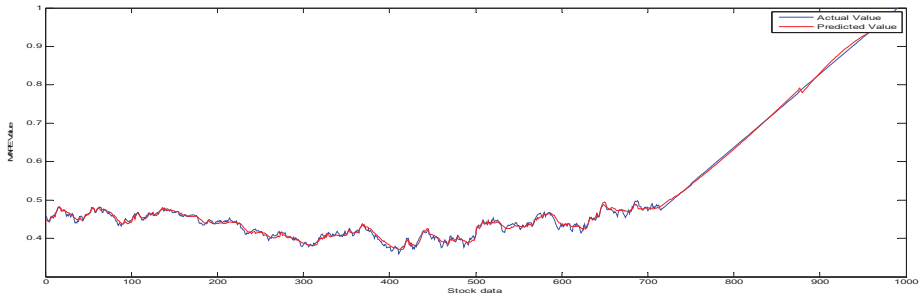
As explained, predicted next-day-close price from two ANN models namely EBPN and RBFN are compared with actual next-day-close price in terms of MAPE, RMSE and MAE and presented in Table 1. This table shows the result for EBPN and RBFN, which is quite satisfactory as MAPE in case of seven features is 2.614 and 2.627 respectively in case of EBPN and RBFN, which is lower than that of MAPE of 14 features as 2.742 and 2.841 respectively for EBPN and RBFN.

Figure 5 (a) and (b) depicts comparison of predicted and actual next day close price data in case of EBPN and RBFN respectively, the results are compared with original data and found that smoothing of non-linear stock data using SWT in combination of two ANN techniques: EBPN and RBFN produces better result.

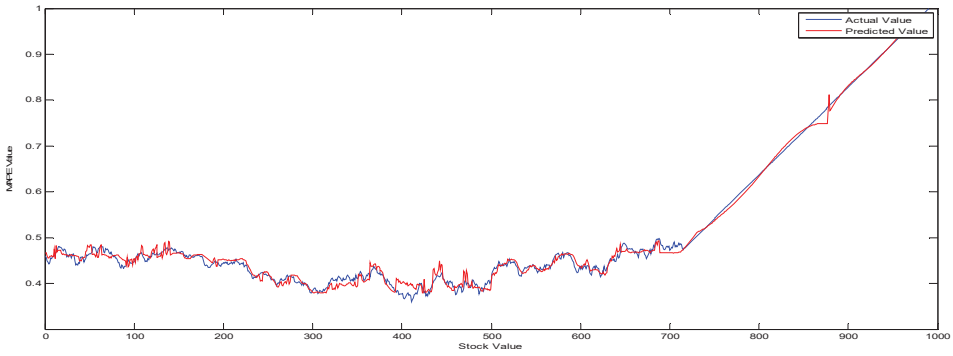
Table 1: Results after applying feature selection technique using EBPN and RBFN

Model	No of Feature	MAPE	RMSE	MAE
EBPN	16	2.737	0.030	0.008
	14	2.742	0.030	0.016
	13	2.618	0.034	0.015
	11	4.355	0.042	0.025
	10	2.644	0.035	0.016
	9	4.154	0.040	0.024
	8	4.058	0.036	0.022
	7	**2.614**	0.034	0.015
RBFN	16	2.851	0.037	0.011
	14	2.841	0.042	0.018
	13	3.001	0.038	0.0175

	11	2.640	0.034	0.015
	10	3.257	0.042	0.019
	9	3.993	0.048	0.024
	8	2.796	0.039	0.017
	7	**2.627**	0.037	0.017



(a)



(b)

Figure 5: Comparative graph in between actual and predicted values (a) For EBPN (b) For RBFN.

IV. CONCLUSION

ANN based techniques learns the pattern by mapping input with corresponding output. If there are variations in input output pattern, ANN may not map pair of input output in better way. In order to overcome this problem input patterns are required to be De-noised (Remove noise from the pattern). Wavelet transform like SWT may be the best alternative for this. In this paper SWT is used to de-noise the data with 16 extracted features and the data are supplied to ANN after applying ranking based features selection technique. Proposed hybridization of SWT and ANN produces comparative better results.

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