A Hybrid Intelligent Artificial Neural Network Model for Stock Market Index Prediction

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ABSTRACT
Emergent trends in computing use hybrid approaches to solve optimization problems. Such hybrid model comprising of soft computing technique based on neuro-fuzzy approach and an optimization technique based on fire fly algorithm is proposed in this paper. Firstly, this paper describes some existing techniques on which it is based. Then the new technique, its algorithm, benefits, result and error is elaborated. In this paper we have proposed an efficient model to predict the closing index value of financial market. Comparison with other existing models shows better accuracy in predicted output. The mean absolute percentage error (MAPE) obtained using this model is 0.0753.

Keywords
Neuro fuzzy algorithm, firefly algorithm, computational intelligence, hybrid models, Prediction

1. INTRODUCTION
Prediction is a useful technique for stock market investors. It plays a vital role in decision making. Hybrid computational intelligence systems modeled to forecast the stock market price helps investors to gain profit by its better accuracy. Fuzzy logic models have become more and more attractive to researchers in both theory and practice. Researchers use fuzzy systems not only to tolerate imprecise information, but also to make a framework of approximate reasoning [1]. The market operators take advantage of forecasted prices in order to compute various indexes and measurements for market monitoring [2]. Artificial intelligence (AI)-based inference models such as the artificial neural network (ANN) and fuzzy logic (FL) are viewed increasingly [3] as viable approaches to various predictions. AI-based inference models simulate human inference processes [3]. Firefly is a nature inspired meta-heuristic optimization algorithm used in this model to optimize the parameters of the neural networks.

2. LITERATURE REVIEW

2.1 Prediction of Stock Price Using an Adaptive Neuro-Fuzzy Inference System Trained by Firefly Algorithm
The stock market brings many benefits by raising the capital of company, aiding in company development, reallocating wealth and government capital raising [1]. This paper uses Adaptive Neuro-Fuzzy Inference System (ANFIS) network blended with firefly algorithm. Fuzzy rule based inference system is used for establishing a relationship between the input and output. The firefly algorithm is used to train the ANFIS network parameters. It is used as a time series forecasting system to predict stock market based on Hanoi Stock Exchange (HNX) in Vietnam [1]. This model is used with stock market data of six different companies Asia Commercial Bank (ACB), Vietcombank (VCB), Saigon Thuong Tin Commercial Join Stock Bank (STB), Textbook Printing JSC in Ho Chi Minh (SAP), Education Book JSC in Ho Chi Minh (SGD) and Hanoi Textbooks Printing JSC (TPH). A comparative study is presented in this paper.

2.2 A Novel Hybrid Approach Using Wavelet, Firefly Algorithm, and Fuzzy ARTMAP for Day-Ahead Electricity Price Forecasting
This paper develops a hybrid model by combining wavelet transform (WT) used for data filtering and a soft computing model based on fuzzy ARTMAP (FA). The FA network is optimized using an optimization technique called firefly (FF) algorithm [4]. On comparison of the prediction result of this hybrid model with the result obtained from other soft computing and hybrid models an improvement in daily and weekly mean absolute percentage error (MAPE) is obtained. The average improvement in MAPE by this model over the forecasting models referred in this paper for daily and weekly forecasts are in the range of around 52–58% and 44–53%, respectively. This hybrid intelligent algorithm is further tested utilizing the PJM market data and able to reduce the daily and weekly MAPEs by around 27–40% and 20–30% [4], respectively, when compared with [5].

2.3 Prediction of Petroleum Reservoir Properties using Different Versions of Adaptive Neuro-Fuzzy Inference System Hybrid Models
This paper presents a comparative study of the performance of three versions of Adaptive Neuro-Fuzzy Inference System (ANFIS) hybrid model and two innovative hybrid models in the prediction of oil and gas reservoir properties [6]. ANFIS involves rule based fuzzy logic inference. Neural networks are used in conjunction with support vector machines (SVM) and fuzzy logic to improve the model performance. Datasets from six wells were used for the testing and evaluation of the model. Three wells for porosity and three for permeability factor consideration were used [6]. The SVM showed bettperformance due to reduced dimensionality of data given as input.

3. PROPOSED MODEL

3.1 Fuzzy logic

Fuzzy logic was proposed by Zadeh. It is a popular artificial intelligence technique mostly used for decision making. Fuzzy logic converts crisp input values into fuzzy values. Fuzzy values only range between 0 and 1. Membership functions are applied to the data sets to convert crisp values to fuzzy values. The different membership functions are trapezoidal function, Gaussian function, etc. Rule based fuzzy logic is used for inference.

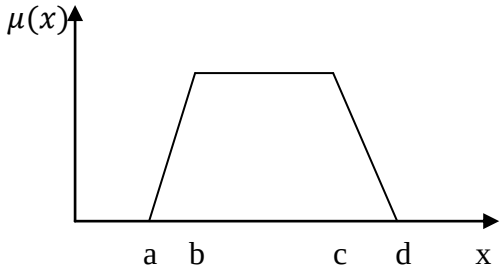

Figure 1. Trapezoidal Membership Function

Here $\mu(x)$ is the membership value of the member x.

$$\mu(x) = \begin{cases} 0, & x \le a \\ \frac{x-a}{b-a}, & a < x < b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c < x < d \\ 0, & x \ge d \end{cases} \qquad (1)$$

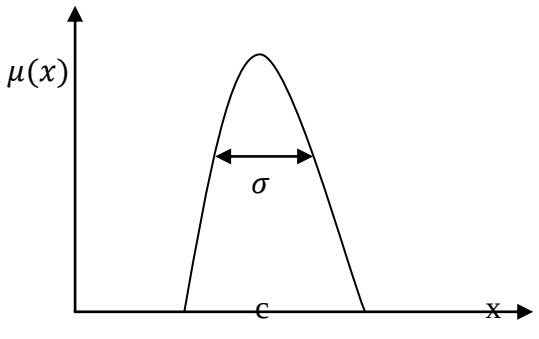

Figure 2. Gaussian Membership Function

Here $\mu(x)$ is the Gaussian membership value, σ is the spread or width of Gaussian curve, c is the center of the curve and x is the membership value.

$$\mu(x) = e^{-\frac{1}{2}\left(\frac{x-c}{\sigma}\right)^2} \qquad (2)$$

Equation 1 and 2 shows the membership function formula for trapezoidal function and Gaussian function respectively.

3.2 Neural Networks

Artificial neural networks are constructed based on the concept of nerve cells of human brain. The nodes of the neural network are connected in a similar fashion like neurons. Networks are categorized basing on the type of learning i.e. supervised learning and unsupervised learning. Artificial neural networks have 3 layers: input layer, hidden layer and output layer. Networks have only one input and one output layer but there can be multiple hidden layers. The nodes of different layers are connected by the intermediate weights.

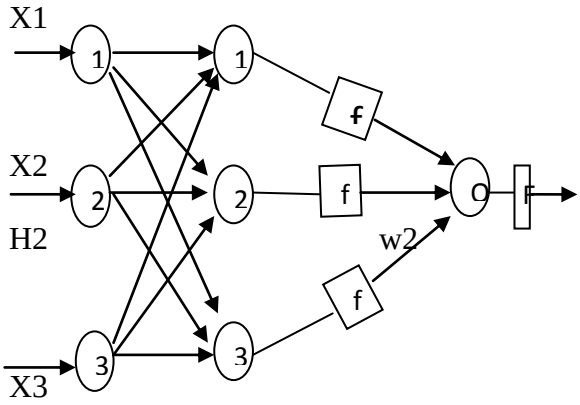

Figure 3. A multilayer perceptron

The above figure shows a multilayer perceptron with 3 layers. First is the input layer, second is the hidden layer and last is the output layer.

$$O = H_i w_i \qquad (3)$$

$$H_i = \sum x_i w_{ij} \qquad (4)$$

$$e = O_{desired} - O_{obtained} \qquad (5)$$

3.3 Firefly algorithm

This is a swarm intelligence optimization technique that is based on the movement of fire flies. The solution of an optimization problem can be assumed as agent i.e. firefly which glows in proportion to its quality. Consequently each brighter firefly attracts its partners, regardless of their sex, which makes exploration of the search space more efficient [7]. Fire flies are attracted towards light. The entire swarm moves towards the brightest firefly. So the attractiveness of the fireflies is directly proportional to their brightness. Furthermore, the brightness depends on the intensity of the agent.

Firefly algorithm

Generate initial firefly population
Evaluate fitness value for each firefly
For max iteration i
For number of fireflies j
For number of fireflies k
If(intensity(k)<intensity(j))
Calculate distance
Move fireflies
End
End
Update brightness and attractiveness
End
End

3.4 Hybrid model

This paper aims at designing a computational hybrid intelligent system comprising of neuro fuzzy technique blended with firefly algorithm. Fuzzification converts the crisp data values to linguistic values. The neural network parameters are optimized using firefly algorithm. The neural network used for this model is multilayer perceptron. MLP has 4 input layer neurons, 4 hidden layer neurons and only 1 output layer neuron. The output of the network is given by equations 3 and 4. The error is determined by equation 5. The mean absolute percentage error (MAPE) is given by:

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\frac{x_i - O_i}{O_i} * 100 \qquad (6)$$

Inputs to the network are opening price index, high price index, low price index and the average value. Output of the system is the closing index value. Firefly algorithm optimizes the neural network parameters. Fitness function evaluates the intensity of the fireflies. Distance (dis) between the fireflies is evaluated, based upon which the attractiveness of fireflies is updated.

$$\text{dis} = \sqrt{(y_i - z_i)^2} \qquad (7)$$

$$A = A_o * e^{-g*\text{dis}^2} \qquad (8)$$

Here A is the attractiveness, A_o is attractiveness at dis=0, g is a constant.
Consequently the movement of fireflies depends on the attractiveness and distance between the flies. The optimized values obtained from the network are used for training.

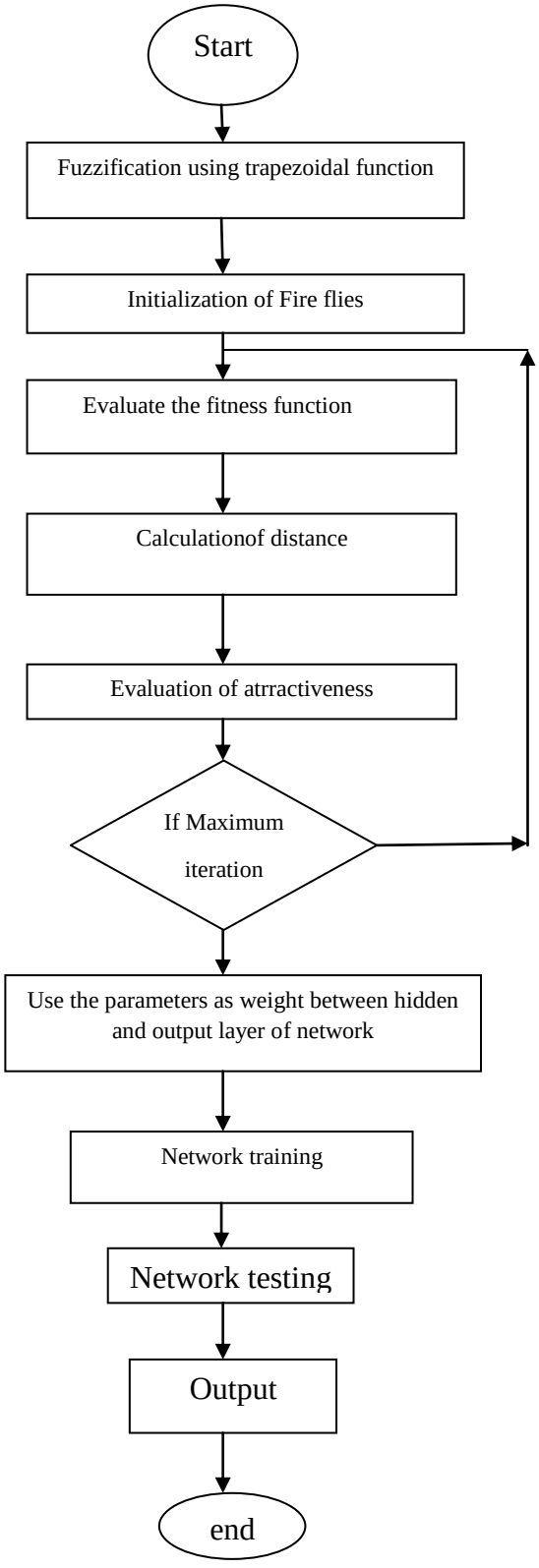

Figure 4. Flow chart of the proposed model

Algorithm:

Step 1: Fuzzification of the dataset using trapezoidal function
Step 2: Initialize the fireflies
Step 3: Set max iteration
Step 4: Evaluate the fitness function
Step 5: Calculate the distance between fireflies
Step 6: Evaluate the attractiveness
Step 7: Update the network parameters
Step 8: If max iterations then go to step 9 else go to step 4
Step 9: Network training
Step 10: Network testing

4. RESULT

The mean absolute percentage error (MAPE) determined from this hybrid model
is 0.0753. This figure is very less in comparison to other models.

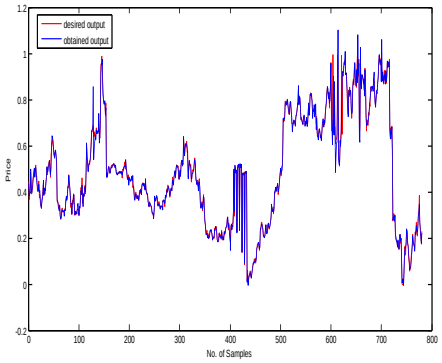

Figure 5. Output from the firefly

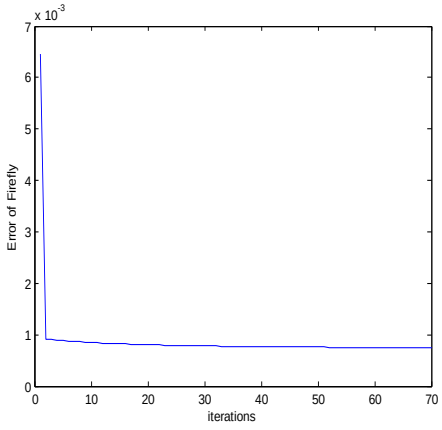

Figure 6. Error of the firefly algorithm

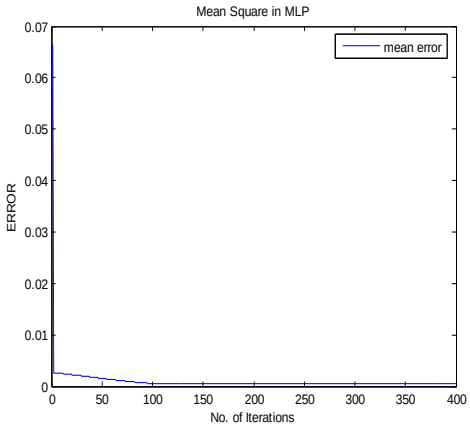

Figure 7. Error of the network

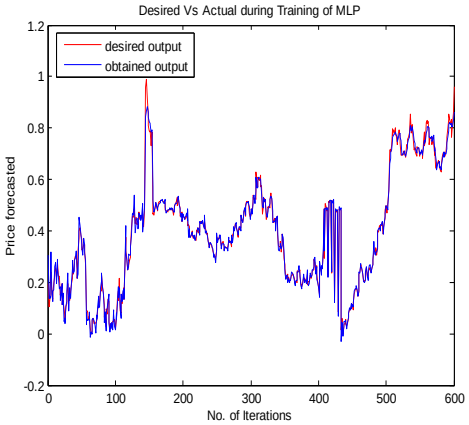

Figure 8. Output from the network training

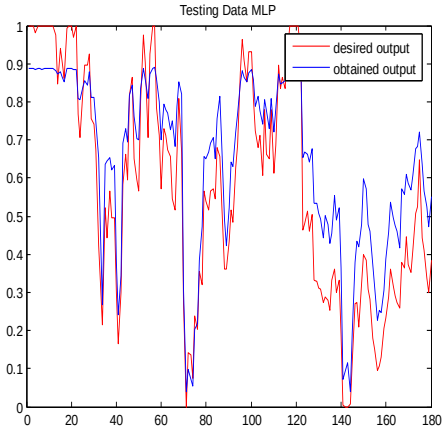

Figure 9. Output of network testing

5. CONCLUSION

Prediction algorithms are on greater demand and would continue to do so. In this paper different models are compared for error analysis and accuracy estimation. This paper uses hybrid computationally intelligent system for prediction. This hybrid model comprises of fuzzy logic, neural network and firefly algorithm. The hybrid model has been implemented by Nokia dataset. Based upon the experimental results it can be inferred that this computationally intelligent system works more efficiently and gives better result in comparison to other existing models. The model gives the closing price index of the dataset used.

This paper takes input parameters as open, high, low and average. Further other parameters like volume, stock index, etc. can be used to improve efficiency and accuracy of the system. Data sets from other fields like renewable resources, bio medical data, meteorological data, etc. can be implemented to this system to prepare an analytical study.

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