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Modeling and Forecasting Stock Prices Using an Artificial Neural Network and Imperialist Competitive Algorithm

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Abstract

In recent years, computer has become powerful tool for prediction of economical and financial variables. Different techniques of topics related to artificial intelligence, machine learning, and expert systems extended their place in the economic and financial issues that among these issues can refer to techniques of artificial neural networks, neural networks and fuzzy neural networks and Recurrent Neural Networks. In this paper, by using a hybrid model of multi-layer Perceptron artificial neural network and Imperialist competitive algorithm has been paid and present a method to predict stock price. The results of this implementation indicate a relatively high capacity hybrid model of artificial neural networks and Imperialist competitive algorithm to predict the stock market price of the Tehran Stock Exchange.

Keywords: Imperialist Competitive Algorithm, Artificial Neural Networks, Forecasting Stock Price, Multi-Layer Perceptron

Introduction

Investment in shares that Released in the stock market, is one of the most lucrative options in the capital market. Thus, despite the complexity of the stock market, forecasting stock prices are very important to shareholders. Researches show that shares price in the Tehran Stock Exchange stock does not change randomly. On the other hand, because stock market is like a nonlinear system, that influenced by political, economical and psychological conditions, it can be possible to use non-linear intelligent systems such as neural networks, artificial neural networks, fuzzy logic Networks, Recurrent Neural Networks and so on for predicting stock prices (Abzari & Shavazi, 2006).

The aim of this study is to determine the stock price prediction error by using a hybrid model of multi-layer perceptron artificial neural network and Imperialist competitive algorithm.

This research data that includes shares price, the highest price of shares, the lowest price of shares and trading volume of the 12 companies participating in the Tehran Stock

Exchange, and is collected by library method. To implement Artificial neural networks, and obtaining the results, software MATLAB (R2009b) that is one of widely used software in the fields of computational and statistical issues has been used.

In the second part, multi-layer perceptron artificial neural network is described. The third section introduces the Imperialist competitive algorithm. In Fourth part, how to implement a hybrid model of artificial neural networks and Imperialist competitive algorithm of this research is presented and Section V is conclusion.

Artificial Neural Networks

Artificial neural networks are based on the organization of neurons and decision making process in the human brain (Varahrami, 2011). In other words, these networks are very simple mathematical models of the human nervous system that can be used for prediction, pattern recognition and pattern classification (Varahimi, 2010).

Many researchers acknowledge the appropriate application of artificial neural networks in complex systems, non-linear and such chaos (DilipNachane, 2009).

Artificial neural network performance depends on three major factors. These three factors are:

- 1) Network topology;
- 2) Network training algorithm;
- 3) Transfer Function (DiTollo, 2008).

Artificial neural networks are generally formed of an input layer, an output layer and one or more hidden layers. Network by determining Weights of interfaces between its layers trained and when training and test process is finished, can expect to see the proper output in the output layer (Mollaiy & Shahbazian, 2011).

Stage of neural network training, can be done in various ways, among which are genetic algorithm (inspired from biological evolution of humans and other species), ants colony optimization (Ant-based optimal motion), Simulated Annealing (SA) (excerpted from the refrigeration process metals), Imperialist Competitive Algorithm (ICA) (derived from social evolution - the human person) and so on.

Multi-layer Perceptron Networks

Multi-layer perceptron network is one of the most widely used types of artificial neural networks in finance and economics (Varahimi, 2010). These networks encompass several layers of computational units (neurons) that generally act in a Feed Forward direction. In Perceptron artificial neural network, each neuron in each layer is connected directly to all the neurons of the next layer. In Figure 1, a three-layer perceptron network can be viewed.

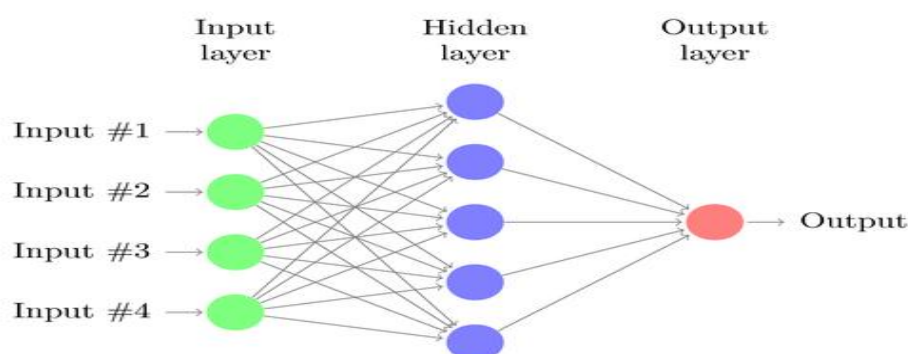


Figure 1. A three-layer perceptron with complete connections

The number of neurons in each layer is independent of the number of neurons in other layers. According to Figure 1, in the act Circle, sum and threshold investment (through transfer function) is carried out. In fact, each solid circle in Figure 1 is a model of collecting and threshold investment block that is shown in Figure 2:

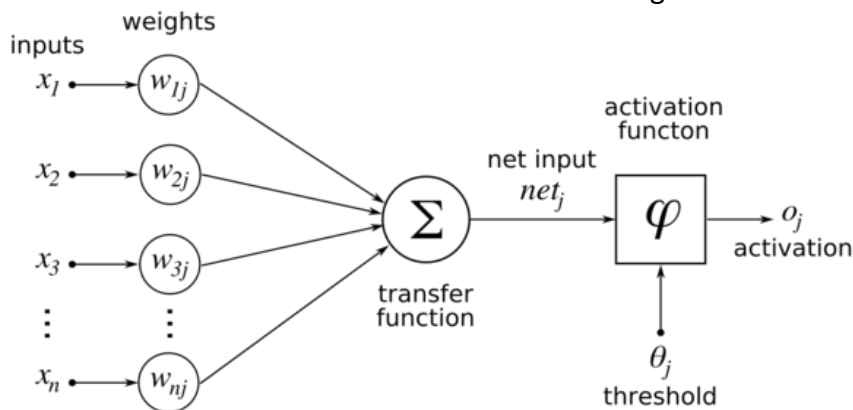


Figure 2. A simple mathematical model of a real neuron

The output of neuron is obtained based on a function criterion (transfer function). In Most of the financial and economic problems, sigmoid function is used as transfer function that this function is defined in equation 1.

$$\text{sgm}(x) = \frac{1}{1 + e^{-x}} \quad (1)$$

In this equation Value of x is the difference between the network output and the desired output of the network that in this research the desired output is the daily stock price, and the output of the network is the value which would result in network performance with weights and that moment inputs. Neurons i th output (the output layer) can be found in the form of equation 2.

$$O_i = \text{sgm} \left(\sum_m \text{sgm} \left(\sum_l x_j w_{lm}^h \right) w_{mi}^o \right) \quad (2)$$

h, o , in equation 2, represents the hidden layer and output layer respectively and the purpose of w is layers weight. Sgm is also sigmoid function that always generates a value between 0 and 1. Performance of Sigmoid function can be seen in Figure 3.

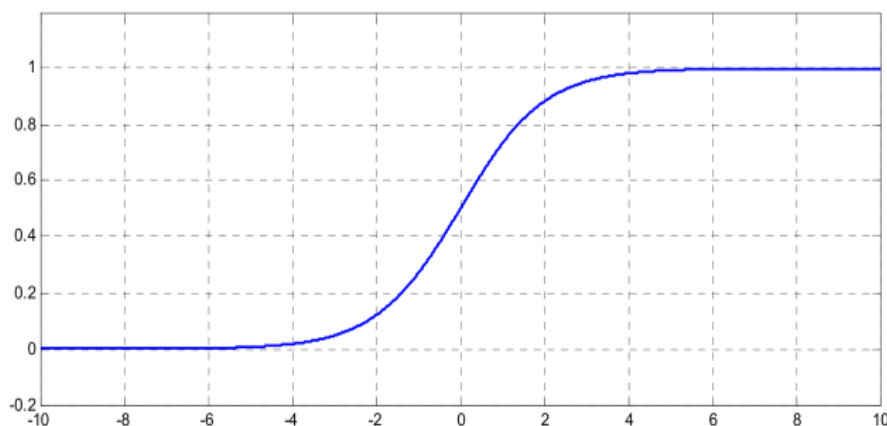


Figure 3. Performance of sigmoid function

Obviously if sigmoid function is not selected as transfer function, the output of each neuron and the resulting network output would be different. Most researches in the field of economical and financial issues sigmoid function is used as the transfer function (Jamal et al, 2008).

Imperialist Competitive Algorithm

Imperialist competitive algorithm is a new algorithm in evolutionary computation field, which, like other evolutionary algorithms, with a random initial population which each of them are called country, begins. Some of the best elements of the population (equivalent capability in genetic algorithms) are selected, as the Imperialistic and the remainder of population considered as Colony (Mollaiy & Shahbazian, 2011).

Imperialist countries through recruitment policy in line of different axes of optimization attract colonies. Imperialist competition alongside recruitment policy, constitute the core of this algorithm and Causes the country to move toward the absolute minimum cost function. Depending on their power, imperialists, encourage colonists to follow them. Power Of each empire is depends on both components of Imperialist (the central core) and its colonies. In the case of mathematical this Dependence is modeled by definition of imperial power in the total power of the Imperialist plus a percentage of the average power of its colonies (Atashpaz Gargari, 2010). Equation 3, shows the total power of an empire (Giandomenico, 2008).

$$T.C._n = \text{Cost}(\text{imperialist}_n) + \xi \text{mean}\{\text{Cost}(\text{colonies of empire}_n)\} \quad (3)$$

Imperialist Competitive Algorithm Performance

Imperialist competitive algorithm performance can be summarized in below steps [2]:

1. Select some random spot on the function and form initial Empire.

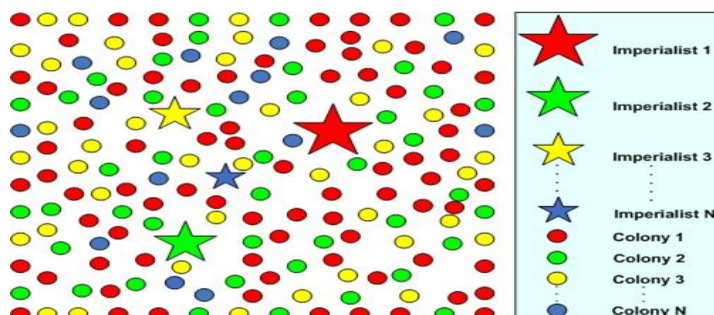


Figure 4. Formation of the initial empire

2. Move Colonies to the Imperialist country (Recruitment policy).

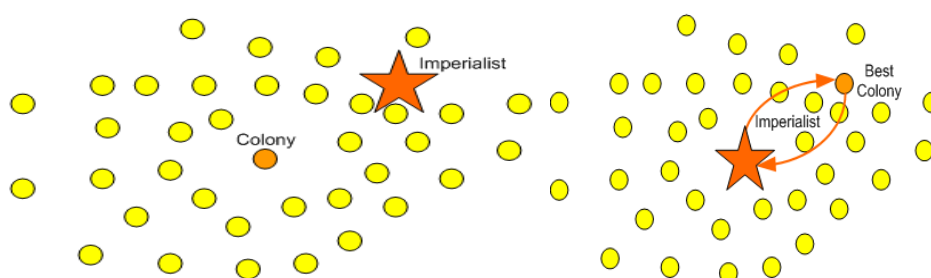


Figure 5. Moving colonies toward Imperialists

3. If there is a colony in an empire which has lower cost than the Imperialists, change the colony and the Imperialist.
4. Calculate the total cost of an Empire (considering the cost of their colony and the Imperialist.)
5. Select a colony of the weakest empire and Deliver it to the empire that is most likely to be attracted.

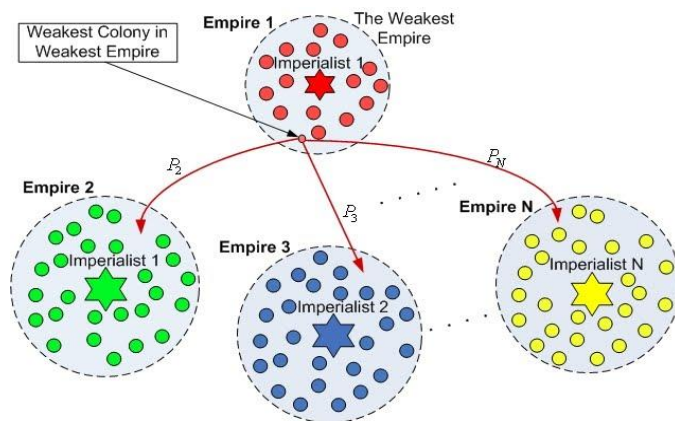


Figure 6. Absorption of the other empire's colonies by stronger Imperialist

6. Remove weak empire.
7. If only one empire remains stop, otherwise go to step 2.

It should be noted that in some cases colonies revolution that this case, should also be considered in implementing the algorithm.

Implementation of the Algorithm and Computational Results

In this research, for Implementation of hybrid model of artificial neural network and Imperialist competitive algorithm to determine the stock price prediction error (using the Mean Square Error), the MATLAB (R2009b) software is used.

To obtain the desired results, the input data including share price, highest price, lowest price and trading volume is standardized and therefore all input data Have been placed in [0, 1] range. Then the perceptron network with four neurons in the input layer, 4 neurons in the hidden layer and 1 neuron in output layer have been created. The number of neurons in the input layer is equal to the number of entries. Number of hidden layer neurons, which is the desired value, is obtained by trial and error that it is intended and value 4 is considered for it. The number of neurons in the output layer is equal to the outputs and because the network output is the stock anticipated price, therefore, be considered equal 1.

Transfer function also as Transfer function that used in many of artificial neural networks is considered sigmoid function.

As has been stated in 3-2, to implement Imperialist competitive algorithm, at first initial empire must be formed. For this purpose, 200 random number in the [0, 1] range, as the weights of the network has been created. These weights are the countries in Imperialist competitive algorithm. Among these 200 countries, 8 countries that primary had lower cost have been selected as the initial Imperialist which the initial cost is also the difference between neural network output and the desired output in the first cycle. Likelihood for revolution of each colony is considered 0.3. A period of time (date) for the development of the empire is considered 2000 years. It should be noted that the number of countries, the

number of initial Imperialist, rate of revolution and period of time in Imperialist competitive algorithm is determined by trial and error. After that data for 4 companies in Tehran Stock Exchange which include stock price, the highest price, the lowest price and the trading volume of over 2 years (from February 2007 to March 2009) has been given to network. The companies list is in Table 1.

Table 1. List of reviewed companies

Irankhodro Diesel	Tehran Cement
Medicine Azabayjan	Khuzestan Cement

By entering the data for each company, the following results are obtained for the stock price prediction minimum error that can be seen in Table 2.

Table 2. List of companies and their MSE

Company	MSE
Irankhodro Diesel	0.0044025
Medicine Azabayjan	0.0028101
Tehran Cement	0.0028060
Khuzestan Cement	0.0040941

After starting the network, by closing the algorithm to the end of period (2000 years) the value of the mean square error is reduced. This reduced rate is not constant. But Beginning of it is with a rapid rate and the rate continues to slow. Til at the end of period this reduce will not be tangible, and eventually time, doesn't help to reducing the error rate. This can be seen in the charts below.

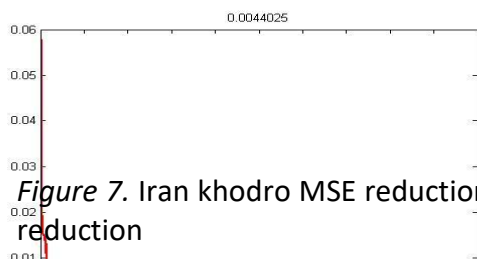


Figure 7. Iran khodro MSE reduction

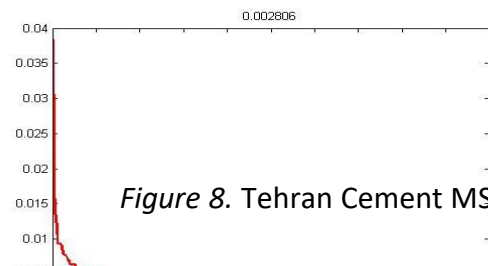


Figure 8. Tehran Cement MSE

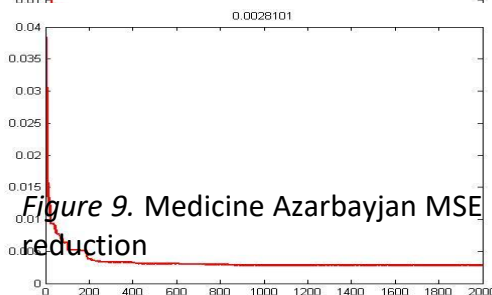


Figure 9. Medicine Azarbayjan MSE reduction

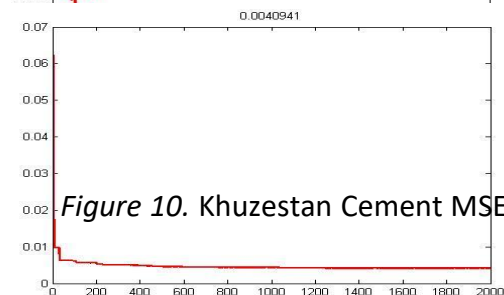


Figure 10. Khuzestan Cement MSE

According to The MSE charts, it is clear that the first Imperialist still not start its Imperialist competition, the amount of networks error is high, But with time, and Imperialist's competition over colonies absorption And also the possible revolutions, network error is reduced but not to zero.

It is obvious that by changing any of the perceptron network parameters ,As the number of neurons and the type of function or changing Imperialist competitive algorithm parameters

Like the number of countries, and the number of initial Imperialist, graphs of the mean squared error will have different forms, but the differences are not necessarily tangible.

Conclusions

In this paper, by using combination of artificial neural networks perceptron and Imperialist competitive algorithm a method to predict stock prices is presented and according to obtained charts of the implementation of the hybrid model of neural network algorithm and Imperialist competitive algorithm it is obvious that this method can be useful greatly for predicting stock prices. By expansion of Imperialist competitive algorithm the other evolutionary optimization algorithms and Combining these algorithms with a variety of artificial intelligence techniques such as artificial neural networks, finding appropriate answers for issues raised in finance and economics, can be achievable.

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