A New Approach to Predict Stock Big Data by combination of Neural Networks and Harmony Search Algorithm

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***Abstract*— Nowadays, due to the vast volume and complicated interrelation of daily stock data, the prediction of the stock price is very crucial in order to earn the highest profit of the shareholder's investment is the main target. For these purposes, data mining techniques such as correlation analysis and prediction, and likewise data modeling and pattern recognition are utilized.**

Since the stock market is a chaotic and nonlinear system, the exact prediction of the massive data exchange, requires intelligent and advanced tools such as neural networks and meta-heuristic algorithms. This purpose method is conducted on the stock data of IBM, Apple and Dell companies and gold price in the global market. Moreover, the prediction error is compared with results of ARIMA[1], ANN[2], HMM[3] ANN-ICA[4], ANN-GA[5], ANN-PSO[6], HMM-Fuzzy [7] , HMM-ANN-GA [8] methods. The comparison indicates that the purposed method provides remarkable improvement in the prediction performance.

Keywords- Data mining, Big Data, Predict Stock Price, Artificial Neural Network, Harmony Search Algorithm

I. INTRODUCTION

Human population growth and increasing demand for goods and services, at the same time spirit of consumerism, also the limitation of the traditional means in providing needed financial resources to develop and increase production capacity, further provides a context to use the new mechanisms in order to attract the financial resources and lead it into production [26,35].

Continues development of the economy of society has caused a rapid increase in capital markets in different countries. As a result, all investors need the robust and reliable tools to predict stock prices [34]. There are various methods to predict Stock market which divides into two groups: traditional methods and modern methods. Traditional methods consist fundamental and technical analysis. Fundamental analysis includes stating some factors such as global economy, political situation, the annual budget of the country, supply and demand in related markets, market share and so on. The technical analysis predicts future changes in stock prices based on the previous events. Technical analysis believes that the history will repeat itself and future changes in stock price can be determined considering previous stock prices [22, 23, 37].

Just like all of the forecasting methods, these methods can't have an exact Prediction of change because stock big data is very wide spreading. Inability to predict stock price due to different reasons causes offering the "Efficient market hypothesis". According to this hypothesis, pricing securities in the market is influenced by the sellers and buyers reaction toward the latest information and the company future [15].

In general, these methods are based on the statistical data while the stock market is a nonlinear and convulsive one with a wide range of big data that depends on political, economic and emotional factors. Therefore, implementing traditional analyzing tools to make exact decisions about the stock will be so hard and inefficient. In recent years, following the developments in computer technology, artificial intelligence and recognizing chaotic relation in nonlinear time series, different countries try to do some activities to forecast the securities stock price [21]. Artificial intelligence techniques that consist neural networks, Fuzzy logic and Meta-heuristic algorithm including Genetic algorithm, Harmony search algorithm, Firefly algorithm, Hill-climbing and optimization mass particle algorithm and etc., leads to successful results in this field [2, 25]. Some of the meta-Heuristic algorithms are practically faster than others, as a result, users are keener on using this kind of algorithm rather than others. Artificial neural network as an intelligent system can recognize the nonlinear relation between input and output base on a set of data and understanding the basic relations among them. Therefore, in this study, we used artificial intelligence techniques besides harmony search Algorithm and neural network as a modern and smart technique to predict stock market big Data for the first time [1].

[1] Auto Regressive Integrated Moving Average
[2] Artificial Neural Network
[3] Hidden Markov Model
[4] Combination of ANN and Imperialist Competitive Algorithm
[5] Combination of ANN and Genetic Algorithms
[6] Combination of ANN and Particle Swarm Optimization
[7] Combination of HMM and Fuzzy System
[8] Combination of HMM and ANN and GA

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II. LITERATURE

White [38] used a neural network for the first time to Predict stock Market. He focused on this question: "are the neural networks able to identify nonlinear rules in time series and unknown rules in changes of properties and stock prices?" White purpose of presenting this paper was to show one feed forward neural network can do this task .He proved this issue by showing an example of daily prices of IBM.

The neural network entered the financial domain after White's primary study in 1988. There have been many types of research about that; as there were totally 213 scientific activities on the neural network about this case, during 1988 and 1993 [36].

Chiang et al. [8] used one Propagation network to predict the price of a company's net asset at the end of the year. They compared their findings with the obtained result of traditional econometrics techniques. They realized that neural networks act better than Regression methods in a meaningful way.

Aiken [3] used one feed forward neural network trained by Genetic Algorithm (GA) method to predict the interest rates on the treasury of the USA. They conclude that neural network can be useful for this.

Garliuskas [11] has predicted the time series in the stock market using computational algorithm related to kernel function and forecasting method of returning an error. He believes that predicting financial time series by means of the neural network can be better than classical statistics methods and others.

Chan [7] predicted the financial time series using feed forward neural network based on daily data of stock exchanges in shanghai. He used descent Gradient algorithm in order to have higher speed and convergence, also to determine the weights he used multiple linear regression. He concludes the neural network is able to predict the time series more satisfactory. Moreover, choosing weights method led to less computational costs [7].

Lendasse [31] foresaw the index using neural networks. He found out neural networks are better than linear methods.

Egeli et al. [9] forecast the daily stock market index of Istanbul (ISE). The results have shown that neural networks can predict MA (Moving Average) more precise.

Hadavandi et al. [16] predicted stock using artificial neural networks by genetic fuzzy. Here genetic fuzzy was used to decrease the future complexity of price time series.

III. THE PROPOSED METHOD

We implement the scheme using programming in a complete software content MATLAB version R2o12a and a manual coding, as well [1].

A. Input

To recognize the variables we studied a lot and considering the limitation. We have chosen our input variables including open price, high price, Low price and close price in daily stocks of three companies such as Apple Computer Inc., International Business Machines Corporation (IBM), Dell Inc., and the output variable closing stock price on the day after.

It should be noted that to compare the scheme model with other models, we use the train and test dataset as used in other articles [16-19]. Train dataset is from 10 February 2003 till 10 September 2004. Test dataset is from 13 September 2004 till 21 January 2005. AS a whole, test dataset includes 91 data and train dataset also include 400 data [1].

For the date of gold price in global market 80% of data was for training and 20% for test, completely randomly. These data have been considered daily during 2003 and 2014. [2]

B. Input Preparation

The used data as input for the model should be normalized and calibrated. In other words, their vibrations and noise must be reduced or we should change the data in a way that be used as input.

For data preparation, considering the fact that data normalization in the range [-1, +1] distance, we use Eq. (1).

$$x_n = \frac{x - x_{min}}{x_{max} - x_{min}} \times 2 - 1 \quad (1)$$

After normalization by this Equation, the neural network will be designed.

C. Neural Network Design

Multi-layer Perceptron (MLP) neural network are one of the most beneficial neural network used in the most researchers. A propagation algorithm for training this feed-forward multilayer network via stimulus differentiable functions can be used to predict, recognize and classify the pattern [24].

In this paper after necessary studies and comparing various neural networks, we decided to utilize multilayer perceptron neural network. For training, we used to feed forward and harmony search Meta-heuristic algorithm [1].

D. Activation Function

Activation Function clarifies the relation between input and output in a node or a network. This function gives the network a grade of nonlinearity which is very important for most of the neural networks [13]. The best function here for the middle layer is Sigmoid Function.

E. Training Neural Network

In the first Phase of the scheme, our model uses the propagation algorithm. First, it's assumed that the network weights are selected randomly. In every step, the output is calculated according to its difference with the ideal output. Moreover, the weights will be corrected. At the end, this error

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changes to a minimum. The activation function for every nerve, in propagation algorithm, is considered as the weights sum of inputs related to that nerve. As a result, considering this assumption that W is corresponding weights between the input layer and next one, we can introduce Eq. (2):

$$A_j(\overline{x}, \overline{w}) = \sum_{i=0}^{n} x_i \, w_{ji} \quad (2)$$

Clearly we can see that activation function output of nerve is just dependent on the corresponding input weights. Therefore, we should change the weights therewith change the output. As we mentioned before, training goal is to achieve an ideal output. So, first, we should define the Error function for every neuron.

This error will be obtained by calculating the difference between the actual output and expected the output of the network: "Eq. (3)"

$$E_j(\overline{x}, \overline{w}, d_j) = \left[o_j(\overline{x}, \overline{w}) - d_j\right]^2 \quad (3)$$

Selecting the square of the difference between actual output o_j and desired output d_j is controversial from several aspects. First, by using square, the error value will always be Positive. Second, if the difference between actual and desired output is noticeable, then the square will cause this number become larger. Conversely, if this difference is Low, the square will cause the number become smaller. Therefore, the total error of network can be calculated by the total error of every single nerve in output layers. So, we will have "Eq. (4)"

$$E_j(\overline{x}, \overline{w}, \overline{d}) = \sum_j E_j(\overline{x}, \overline{w}, d_j) = \sum_j \left[O_j(\overline{x}, \overline{w}) - d_j\right]^2 \quad (4)$$

Now we should analyze the relation between error and inputs, weights and outputs. There are different methods for these, which the most important ones are a Gradient method, Meta-Heuristic algorithm, Newton's method, Gross-entropy method and etc. [6, 27, 32].

So, we used meta-Heuristic algorithm here in this paper. Harmony search (HS) Algorithm is one of the most simple and the newest Meta-Heuristic methods, which is used in the optimization process that is inspired by the simultaneous playing of the orchestra music. In other words, there is a similarity between finding the optimal Problem solution and the Process of playing the music [39].

Because of its easy operation, little parameters, simple concepts, little mathematical calculations and being practical for newton and continuous optimization problems, Harmony search Algorithm has changed to one of the most useful ones during recent years [30].

Subscribe to the neural network with the meta-Heuristic algorithm, is that phase where after neural network structure design, their training process ends with an optimization problem.

The second phase of the scheme includes 5 steps:

Step 1: instead of f(x) in Eq. (5), we use the error function in Eq. (4):

$$Minimize\ f(x) x_i \in X_i, i = 1,2,\dots,N \quad (5)$$

In this step, these Parameters values are calculated: the Harmony Memory Size (HMS) or the number of solution vectors in the harmony memory, Harmony Memory Consideration Rate (HMCR), Pitch Adjustment Rate (PAR) and Number of Improvisation (NI).

Step 2: creation and shaping of Harmony Memory which is set based on the matrix in Eq. (6).

$$HM = \begin{bmatrix} x_1^1 & x_2^1 & \cdots & x_n^1 & f(x^1) \\ x_1^2 & x_2^2 & & x_n^2 & f(x^1) \\ \vdots & & \ddots & \vdots & \vdots \\ x_1^{HMS} & x_2^{HMS} & \cdots & x_n^{HMS} & f(x^{HMS}) \end{bmatrix} \quad (6)$$

In this step as you can see the matrix of Harmony memory is randomly formed by real performance function f(x) and generating solve vector, which acts as the memory from now on.

Step 3: this step is the most important step of a harmony search algorithm because all of the changes in present harmonies will happen here.

Considering Eq. (7), HMCR clarifies that in forming New Harmony how much inner harmony memory should be used and (1-HMCR) shows the probability of creating the new Random harmony.

$$\acute{x_\iota} \leftarrow \begin{cases} \acute{x_\iota} \in \{x_i^1, x_i^2, \dots x_i^{HMS}\} & w.p\ HMCR \\ x_\iota \acute{\in} X_\iota & w.p\ (1 - HMCR) \end{cases}, HMRC \in [0,1] \quad (7)$$

For example, one HMCR 95% shows that the harmony search algorithm, chased 95% of saved values in harmony memory and only 5% will be random.

The value of 1 for HMCR isn't recommended. Because the total improvement of the solution will work through saved values in harmony memory to offer the best solution.

When one value is chosen from inside the memory, it can change based on PAR probability. "Eq. (8)"

$$\acute{x_\iota} \leftarrow \begin{cases} Yes & w.p\ \ PAR \\ No & w.p\ (1 - PAR) \end{cases}, PAR \in [0,1] \quad (8)$$

The value of (1-PAR) sets the rate of doing nothing. If the pitch adjustment decision for $\acute{x_\iota}$ is YES, $\acute{x_\iota}$ is replaced as follow: "Eq. (9)"

$$\acute{x_\iota} \leftarrow \acute{x_\iota} \pm rand \times BW \quad (9)$$

Where, BW is an arbitrary distance bandwidth and is rand a random number between [0,1].

Step 4: In this step, if the New Harmony is better than the worst member in memory, the New Harmony will be replaced with the old one, afterward, the worst harmony will be deleted.

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We sort harmony memory based on the best member at the top. As a result, we can update memory in this way.

Step 5: Termination of algorithm happens in this stage. If

the termination doesn't happen, stages 3 and 4 will be repeated again. However, we can adjust the end up the condition of the algorithm to a certain optimal value so repeat the steps of algorithm till the end. (See Fig. 1)

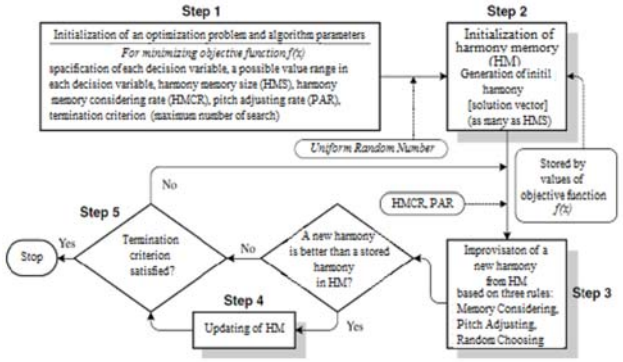

Figure 1. Flow chart of Harmony Search Algorithm

In the proposed phase certain optimal value of Harmony Search Algorithm to achieve the minimum error and the most exact answer are shown in table 1.

TABLE I. CERTAIN OPTIMAL VALUE OF HARMONY SEARCH ALGORITHM

Parameters	*Value*
Maximum Number of Iterations	1000
Harmony Memory Size	500
Number of New Harmonies	250
Harmony Memory Consideration Rate	0.5
Pitch Adjustment Rate	0.1
Fret Width (Bandwidth)	$0.02 \times (\mathrm{var}_{\max} - \mathrm{var}_{\min})$
Fret Width Damp Ratio	0.995

F. Network structure

After identifying the type and method of the network in neural network structure, we should clarify the number of input neuron, the number of hidden (middle) layers and hidden neurons and the number of output neurons.

Selecting the number of inputs is very important. Most of the researchers used trial and error method. To calculate the number of neurons in this paper the number of input neurons is chosen exactly as the amount of network input which means 4 neurons. Moreover, the number of output neurons is one, since dependent variable here is predicting the closing stock price in the next day.

Also, the number of hidden neuron layers plays a very important role in neural network success. The neurons in the hidden layer will help the neural network to discover the characteristics of data.

A neural network having one hidden layer can model every continuous and dependent function. Our desired model can consist of every needed number of neurons (10, 100 ...) we introduced Eq. (10) and Eq. (11) related to this issue that is very helpful: [5,6]

$$\text{No of hidden node} = \sqrt{\text{input} \times \text{output}} \quad (10)$$

$$\text{No of hidden node} = \ln(\text{No of nodes in previous layer}) \quad (11)$$

IV. CRITERION FOR EVALUATING THE PERFORMANCE OF SCHEME

To predict the issues, we used some of the performance criterions to show the relation between data, which is usually related to the error of predicted output and desire real output. We used 5 criterions in this research which are shown in table 2.

TABLE II. PERFORMANCE EVALUATION CRITERIA IN OUR PAPER

Equation	*Concept*	*Name*
$\frac{\sum \lvert e_t \rvert}{N}$	Mean Absolute Error	MAE
$MSE = \frac{\sum_{i=1}^{n} \lvert y_i - \hat{y}_i \rvert^2}{n}$	Mean Squared Error	MSE
$RMSE = \sqrt{\frac{\sum_{i=1}^{n} \lvert y_i - \hat{y}_i \rvert^2}{n}}$	Root Mean Square Error	RMSE
$\text{MAPE} = \left(\frac{1}{n} \sum_{i=1}^{n} \left\lvert \frac{p_i - A_i}{A_i} \right\rvert \right) \times 100$	Mean Absolute Percentage Error	MAPE
$R^2 = 1 - \left[\frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{\sum_{i=1}^{n} (\hat{y}_i)^2} \right]$	Coefficient of Determination (R squared)	R2

V. IDENTIFYING THE NUMBER OF NEURONS IN HIDDEN LAYER

To identify the exact number of nodes in hidden Layer, we operated our scheme on the data of IBM Company in America, considering Eq. (10), Eq. (11) and error test in order to obtain the optimal answer. The results are shown in Table 3.

TABLE III. COMPARING THE RESULT OF SCHEME TO IDENTIFY THE NUMBER OF NEURONS IN HIDDEN LAYERS [1]

MAE	*MSE*	*R2*	*RMSE*	*MAPE*	*Hidden Layer*
0.0736	0.0091	0.9589	0.0956	0.6998	(4-17-1)
0.0721	0.0090	0.9599	0.0949	0.4009	(4-19-1)
0.0712	0.0082	0.9687	0.0906	0.3092	(4-21-1)
0.0771	0.0104	0.9423	0.1021	0.6555	(4-23-1)
0.0776	0.0099	0.9580	0.0994	0.6390	(4-25-1)

As you can see in Table 3 and Figs 2, 3 and 4 we can say that whenever the number of neurons in the middle layer is 21 there is the least error, using MAE, RMSE, and MAPE evaluation criterions.

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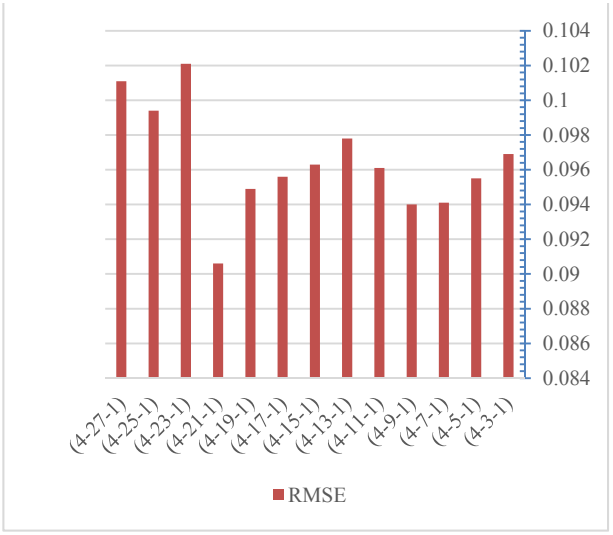

Figure 2. Comparing the number of neurons in the hidden layer based on RMSE evaluation criterion [1]

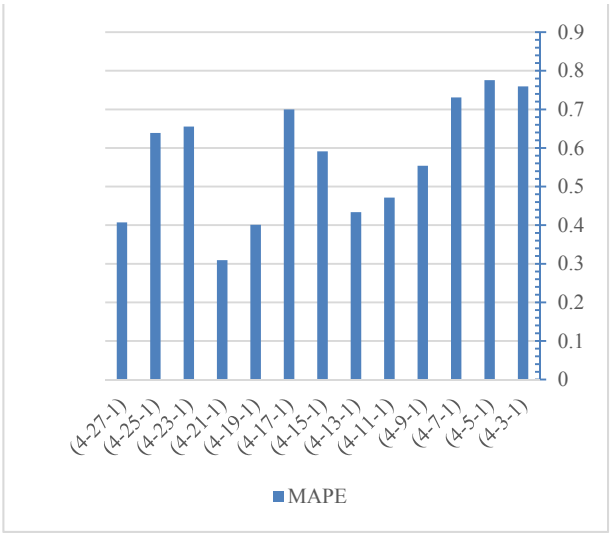

Figure 3. Comparing the number of neurons in the hidden layer based on MAPE evaluation criterion [1]

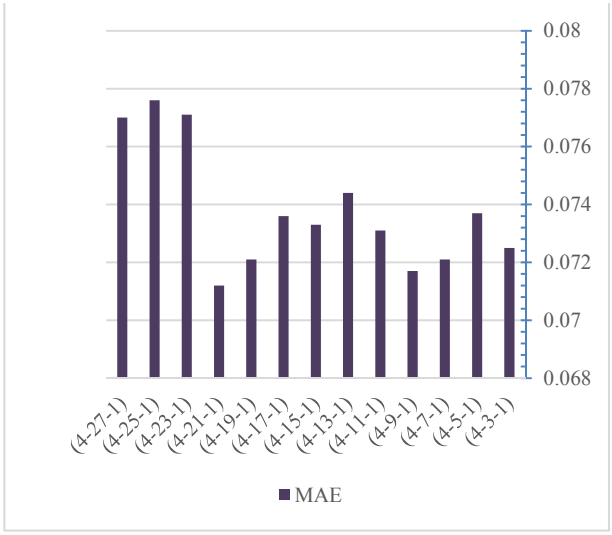

Figure 4. Comparing the number of neurons in the hidden layer based on MAE evaluation criterion [1]

It's necessary to mention that in Fig. 5 and also considering R2 evaluation criterion or the coefficient of determination in (4-21-1) status with 21 neurons in hidden layer there was the highest amount, we know that whenever a Coefficient determination is closer to 1, the model is more accurate and precise.

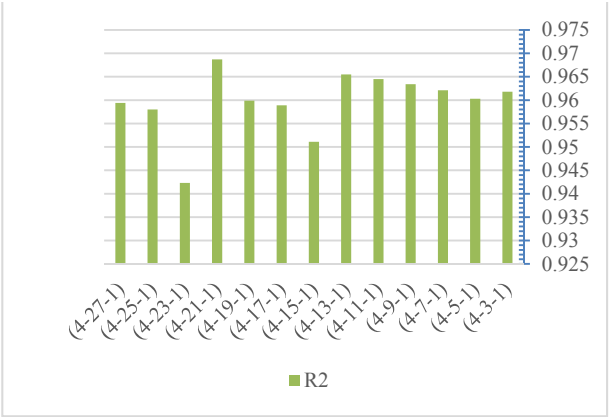

Figure 5. Comparing the number of neurons in the hidden layer based on R2 evaluation criterion [1]

As a result, that mentioned before, the number of ideal layers in this research is 3 (one input layer, one hidden layer, and one output layer) with (4-21-1) number of neurons.

VI. Applying the Scheme to Stock Data of IBM, Apple, and Dell Companies

After a precise identification of neurons, we applied our scheme to stock data of IBM company. Then we applied the same data to the Combination of ANN with ICA, GA, and PSO. The outcomes are shown in Tables 4 and Figs. 6.

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TABLE IV. COMPARING THE SCHEME FOR THE COMBINATION OF ANN WITH ICA, GA AND PSO FOR IBM'S STOCK DATA [1]

MAE	*MSE*	*R2*	*RMSE*	*MAPE*	*Model*
0.1037	0.0175	0.9566	0.1324	0.6010	ANN-ICA
0.0979	0.0147	0.9636	0.1213	0.5936	ANN-GA
0.0966	0.0142	0.9650	0.1190	0.6214	ANN-PSO
0.0955	0.0101	0.9796	0.1006	0.3092	ANN-HS[a]

a. Proposed Method

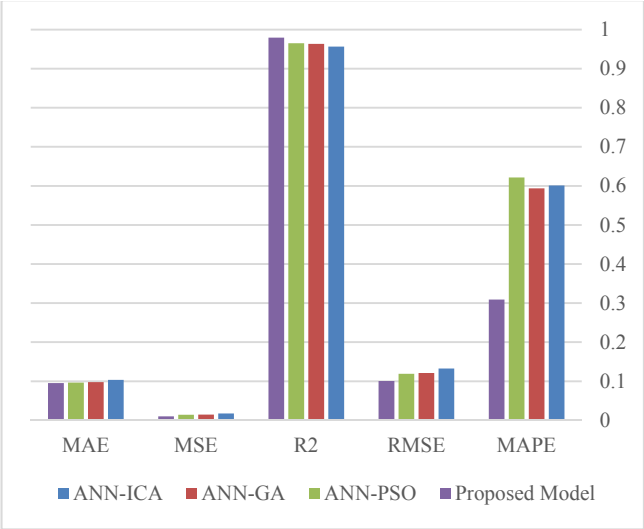

Figure 6. Comparing the scheme for the Combination of ANN with ICA, GA and PSO for IBM's stock data [1]

We applied our scheme to stock data of Dell Company. Then we applied the same data to the Combination of ANN with ICA, GA, and PSO. The outcomes are shown in Tables 5 and Figs. 7.

TABLE V. COMPARING THE SCHEME FOR THE COMBINATION OF ANN WITH ICA, GA, AND PSO FOR DELL'S STOCK DATA [1]

MAE	*MSE*	*R2*	*RMSE*	*MAPE*	*Model*
0.1042	0.0237	0.9504	0.1539	0.1928	ANN-ICA
0.1034	0.0226	0.9527	0.1503	0.1968	ANN-GA
0.0897	0.0185	0.9614	0.1358	0.1602	ANN-PSO
0.0833	0.0139	0.9731	0.1178	0.1447	ANN-HS[a]

a. Proposed Method

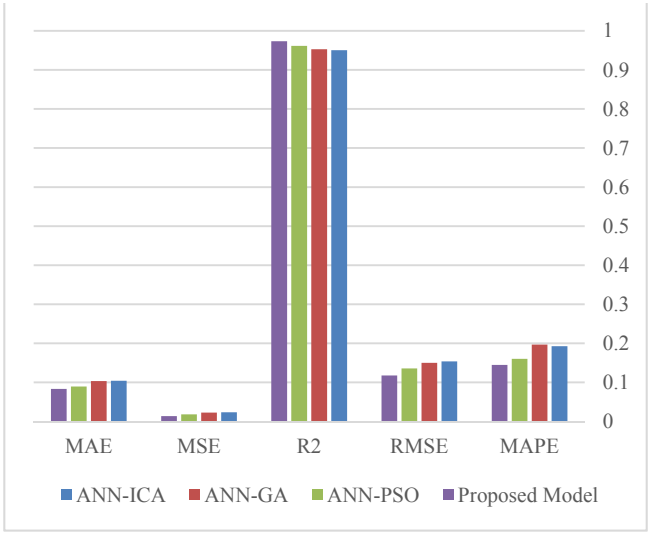

Figure 7. Comparing the scheme for the Combination of ANN with ICA, GA, and PSO for Dell's stock data [1]

We applied our scheme to stock data of Apple Company. Then we applied the same data to the Combination of ANN with ICA, GA, and PSO. The outcomes are shown in Tables 6 and Figs. 8.

TABLE VI. COMPARING THE SCHEME FOR THE COMBINATION OF ANN WITH ICA, GA, AND PSO FOR APPLE'S STOCK DATA [1]

MAE	*MSE*	*R2*	*RMSE*	*MAPE*	*Model*
0.0918	0.0146	0.9646	0.1210	0.3916	ANN-ICA
0.1346	0.0249	0.9399	0.1577	0.5810	ANN-GA
0.0678	0.0098	0.9762	0.0992	0.2311	ANN-PSO
0.0660	0.0069	0.9808	0.0830	0.2074	ANN-HS[a]

a. Proposed Method

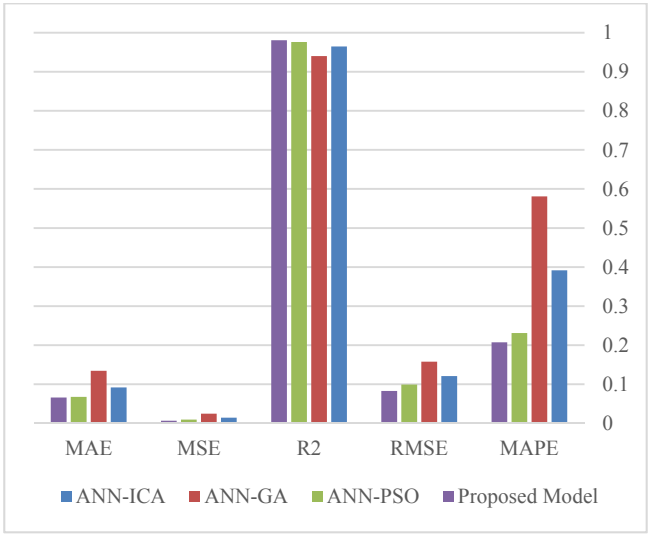

Figure 8. Comparing the scheme for the Combination of ANN with ICA, GA, and PSO for Apple's stock data [1]

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VII. Applying the Scheme to the Price of Gold in Global Market

We applied our scheme to data of the price of gold in global market. Then we applied the same data to the neural network based on ICA, GA and PSO. The outcomes are shown in table 7 and Fig. 9.

TABLE VII. Comparing the scheme for the Combination of ANN with ICA, GA and PSO for gold price in global [2]

MAE	*MSE*	*R2*	*RMSE*	*MAPE*	*Model*
0.0414	0.0026	0.9919	0.0557	0.7715	ANN-ICA
0.0708	0.0066	0.9798	0.0815	0.4750	ANN-GA
0.0612	0.0038	0.9811	0.0623	0.3301	ANN-PSO
0.0403	0.0025	0.9925	0.0500	0.1309	ANN-HS

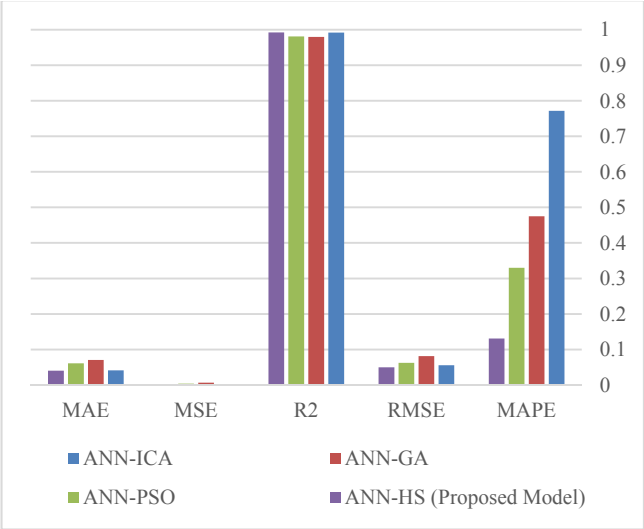

Figure 9. Comparing the scheme for the Combination of ANN with ICA, GA and PSO for gold price in global market [2]

VIII. Comparing the Scheme with Other Algorithms

Considering the fact that predicting the stock price of IBM, Apple and Dell companies has been studied in several types of research till now, we will briefly review the two important papers on data of those mentioned companies to predict the issue. First, in Hassan's [17] Paper there is a new combination of Hidden Markov model and Fuzzy model to predict the stock price. In this paper, first, Markov Model is used to recognize data patterns. Second for predicting the stock Price for next day they used Fuzzy Logic to obtain fuzzy rules .Comparing this combined model with ANN and ARIMA shows the superiority of Markov model.

Second, Hadavandi et al. [16] predict the stock of those companies, introducing a new smart combined model. The prediction of the stock price in this paper is done by designing an expert fuzzy system. The authors extracted the database of the expert fuzzy system by means of Genetic Algorithm. The result was considerably improved in comparison with other papers [17-19]. Table 8 and Fig. 10 compared the scheme with other algorithm used in mentioned papers based on the performance criterion of MAPE which shows the superiority of scheme.

TABLE VIII. Compared the scheme with other algorithm based on MAPE [1]

Dell	*IBM*	*Apple*	*Model*
0.660	0.972	1.801	ARIMA
1.012	1.219	2.837	HMM-based
0.405	0.779	1.796	HMM–fuzzy
0.699	0.849	1.925	HMM–ANN–GA
0.660	0.972	1.801	ANN
0.1928	0.6010	0.3916	ANN-ICA
0.1968	0.5936	0.5810	ANN-GA
0.1602	0.6214	0.2311	ANN-PSO
0.1447	0.3092	0.2674	ANN-HS

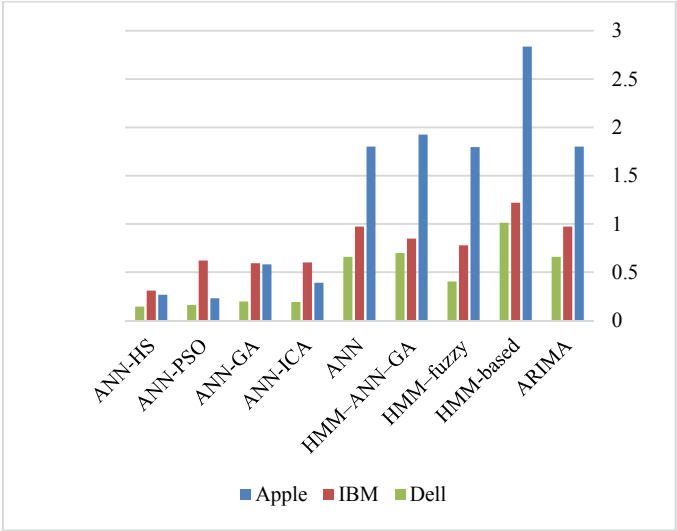

Figure 10. Compared the scheme with other algorithm based on MAPE [1]

Finally, Figs. 11 and 12 we can see that, adaptation of the predicted values to the actual values, confirms the superiority of scheme model.

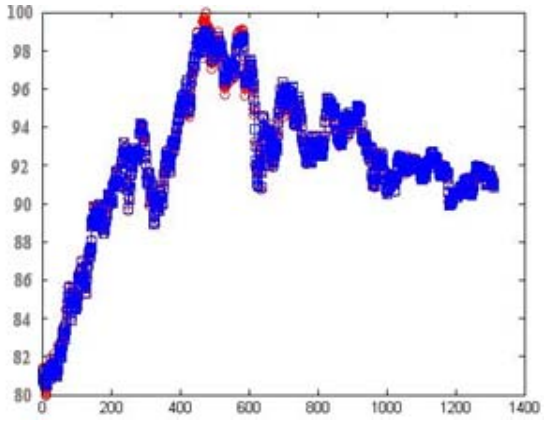

Figure 11. Comparing the prediction based on scheme and real values (far view)

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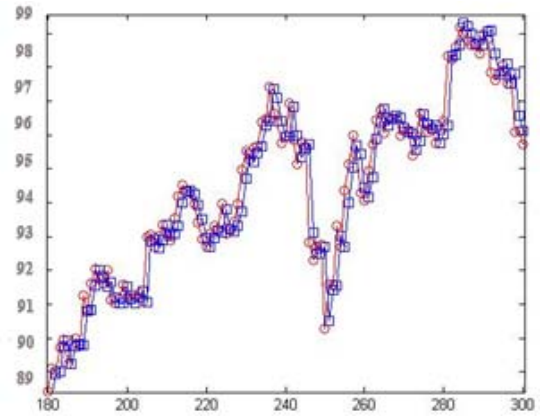

Figure 12. Comparing the prediction based on scheme and real values (close view)

IX. Conclusion

- According to table 8 and Figs. 10 the amount of predicted error by scheme based on performance evaluating criteria MAPE, is more superior rather than other methods. As a result, we could obtain a precise prediction using Meta-Heuristic harmony search.
- According to tables 4, 5 and 6 and Figs. 6, 7 and 8 the amount of prediction error by means of our scheme based on 5 performance evaluation criteria is less than other methods. Therefore, the scheme of predicting the time series of stock Price for IBM, Apple and Dell companies is more accurate rather than other methods in neural network training such as ICA, GA, PSO.
- Considering table 7 and Figs. 9 there were very good result using our scheme. Therefore, predicting the price of gold in global market is considerably accurate using our scheme.
- Number, 1, 2 and 3 of results show that the scheme algorithm on 3 famous active companies in international stock and also on the price of gold in global market, was perfectly predicted. Moreover the Estimation error here was less than other methods. AS a result, our scheme can be used for other time series such as active companies in Iran or international stock.
- As the scheme model includes artificial neural network and harmony search algorithm, is considerably capable to recognize the data patterns. Moreover, it is more superior to other algorithms or methods based on those 5 performance evaluating criteria. Furthermore, results Show that our model has a unique fast convergence, high accuracy and an ability for Approximation function. Also, it is very suitable to predict the stock price index.
- All of the artificial intelligence methods have shown better results rather than traditional and classical methods. Moreover, our scheme method is superior to the classic methods.
- In the scheme method, normalization of data in internal [-1, +1] was very effective in improving data. Therefore, first the data were normalized, then after entering the trained neural network with HS algorithm, they were outside the normal output and were returned to the primary domain.
- Considering the Figs. 11 and 12, the adaptation of predicted values to the actual values, shows the superiority of the scheme model.

X. Future Research Fields

- The approach of neural network based on HS algorithm is a strong method for predicting different issues. As a result, we recommend using this method for other issues including demand prediction, quality control, currency prediction, oil price prediction, medical issues prediction, etc.
- In this paper, we used MLP neural network. Moreover, other neural networks can be used. Such as Radial Basis Functions or RBF or even fuzzy neural network etc.
- In this research, we used the Meta-Heuristic Harmony Search (HS) algorithm in neural network training phase. Moreover, instead of this algorithm, every kind of Meta-Heuristic algorithms such as Gravitational Search Algorithm, Simulated Annual, Hunting Search Optimization and etc. can be used.

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